SCIENCE

JUNE 23, 1950

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THE THEORY OF PHOTOCONDUCTIVITY IN INFRARED-SENSITIVE SEMICONDUCTING FILMS

E. S. RITTNER

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VOLUME 111, NUMBER 2895

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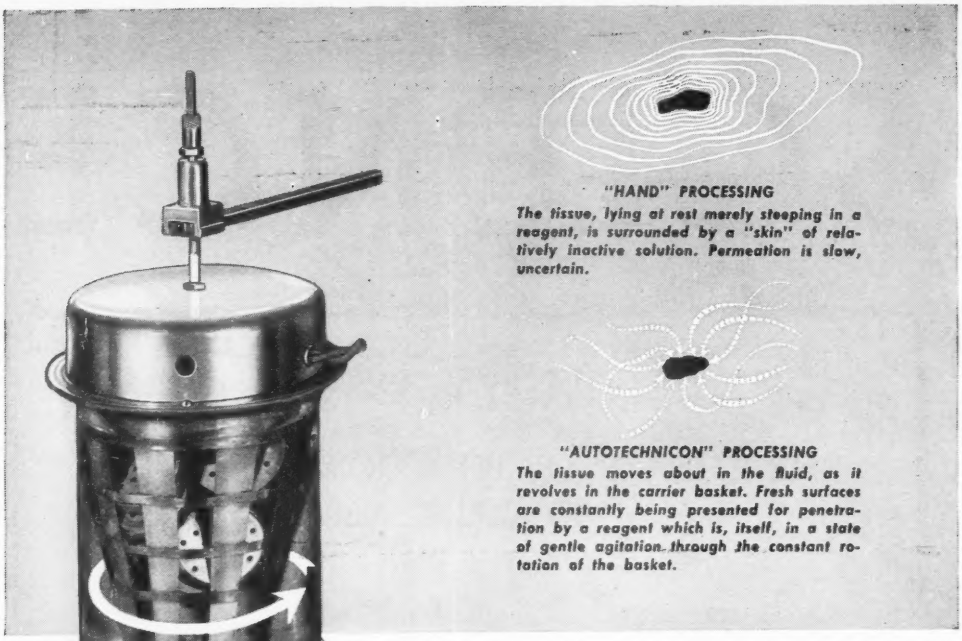
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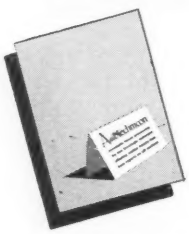

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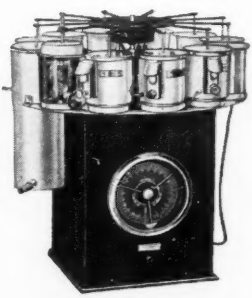

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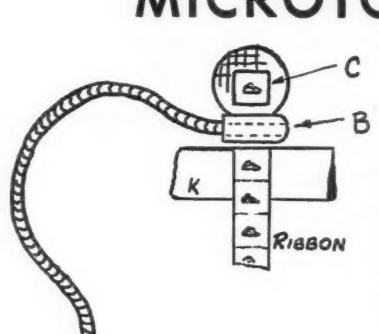

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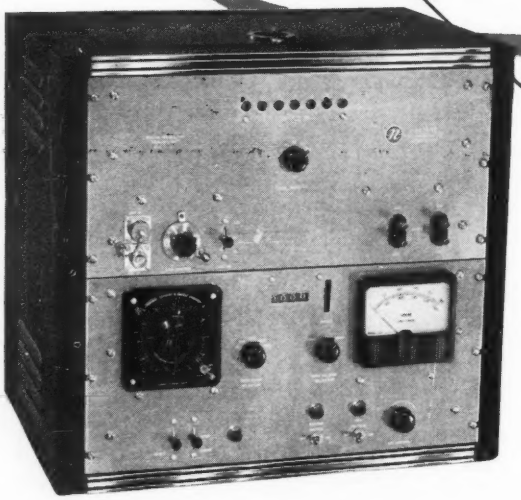

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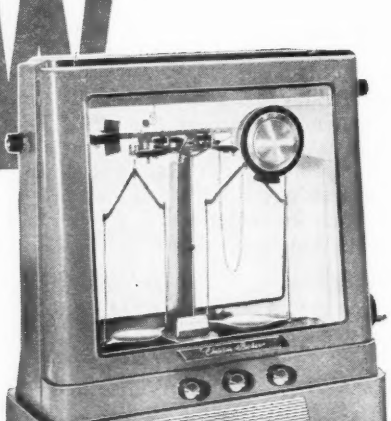

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Yet these same men of action, who have discharged graver responsibilities and solved greater problems, are strangely reluctant to take hold of the wheel of a society that they have in part created. Professionalism—and I am not speaking just of the scientists and engineers—has become almost a badge of living apart from the world, though in it. The chief danger in this kind of thing is in the people left to run other things. The world has never had in any age enough creative people, nor do we have today.

I am glad to see that professional societies like the A.M.A., the A.A.A.S., the A.I.E.E. realize they cannot, and do not, operate on a scientific and technological plane alone. But this job cannot be done by societies, no matter how representative or how efficiently they may operate as societies. Governments are not having much success solving problems at the top level, either.

Engineers have a way of saying: "If we can't solve a problem one way, we turn it upside down and solve it the other way." If some of our social and political problems can't be solved from the top down, they can be solved the way our society is built, from the bottom up.

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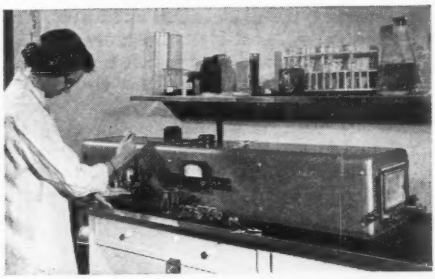

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Concerning the Theory of Photoconductivity in Infrared-sensitive Semiconducting Films[1]

E. S. Rittner[2]

Philips Laboratories, Inc., Irvington-on-Hudson, New York

THE PROPERTIES of Tl_2S, PbS, PbSe, PbTe, and other infrared-sensitive photoconductive cells are so strikingly similar as to suggest that a single explanation should apply to this class of materials. At present three different pictures to account for the properties of specific systems are in use: 1) The photosensitivity is characteristic of a uniform "intrinsic" semiconductor produced by detailed balancing of *n*- and *p*-type impurities. 2) The photosensitivity arises from the presence of a large number of *n*-*p* barriers, distributed at random. 3) The photosensitivity is characteristic of an impurity semiconductor. The first picture has been proposed by von Hippel and Rittner (*10*) for Tl_2S and has been further considered by the writer (*5*) in connection with the behavior of PbS; the second has been advanced also for PbS by Sosnowski, Starkiewicz, and Simpson (*7*) and has been further developed by James (*3*); the third has been proposed recently by Genzel and Muser (*2*) for PbS and also by Simpson (*6*) for unoxidized PbSe and PbTe.

We believe that the third picture may be ruled out on the basis of existing absorption data (*4, 6, 9*) which correspond to large absorption coefficients, of the order of 10^4 to 10^5 cm^{-1}, over most of the spectral range of Tl_2S, PbS, PbSe, and PbTe photocells, thus implying fundamental rather than impurity absorption. The two remaining pictures appear to be mutually exclusive, and as a general explanation of photoconductivity in semiconductors, each is subject to difficulties. The first one fails to explain a-c resistance data (*1, 5*) on PbS cells and carries the extremely stringent requirement that the *n*- and *p*-type impurities balance each other so exactly that the maximum net impurity concentration anywhere in the layer be less than the intrinsic concentration of charge carriers (10^{16}/cm^3 in PbS or 10^{11}/cm^3 in Tl_2S at $T = 300°$ K). The second picture fails to account for the bimolecular recombination law that has been observed in Tl_2S (*10*), PbS (*5*) and PbTe (*6*) photocells. It is the purpose of this note to present a more general explanation of the phenomena observed in infrared semiconductors, an explanation which follows naturally from one method of preparing the photocells and which reduces in limiting cases to essentially pictures (*10*) or (*5*), while avoiding the difficulty of the exact balancing of impurities.

It is perhaps not unreasonable to assume that the following events occur in the course of fabricating photocells by vacuum evaporation and subsequent sensitization. During vacuum evaporation of the material to form a thin layer, a slight loss of the electronegative constituent occurs, giving rise to an *n*-type semiconductor in which the photosensitivity may be extremely small, owing to the rapid recombination of the electrons and holes created optically with the thermally produced ionized donors and free electrons respectively. Subsequent heat treatment in the presence of the electronegative constituent or oxygen converts portions of the surfaces of the grains into *p*-type material, thus calling into existence randomly distributed local *n*-*p* transition regions. As the "oxidation" proceeds further, the *n*-type conducting paths become more and more disrupted by the *p*-type regions, until a point is reached where all charge carriers traveling between electrodes have to pass through some of the *n*-*p* transition regions. With still further "oxidation," continuous threads of *p*-type material of negligible photosensitivity are formed, and these grow progressively thicker, until in the limit the layer may become completely *p*-type. With sufficient exposure to oxygen, new phases such as Tl_2SO_2 or $PbO \cdot PbSO_4$ may make their appearance, but the role of these oxidation products will usually be that of an inert surface layer.

The properties of the photocell layer are determined mainly by those of the transition region, which in turn depend upon the details of the impurity distribution. Fig. 1 illustrates the sort of impurity distribution to be anticipated in the sensitization process outlined above, i.e., the interpenetration of an *n*-type region of relatively constant donor concentration with a *p*-type region in which the acceptor concentration tails off with distance. To the left of line 1 in Fig. 1 some of the electrons from the donors fall spontane-

[1] Based on a paper presented at the Conference on Infrared Photoconductors held at the Massachusetts Institute of Technology, March 29, 1950. The work was carried out with the partial support of the Air Materiel Command.

[2] The author is indebted to Dr. F. K. du Pré for a number of stimulating discussions, to Prof. G. E. Uhlenbeck for encouragement and advice, and to Prof. O. Simpson for permission to see a copy of his dissertation prior to publication.

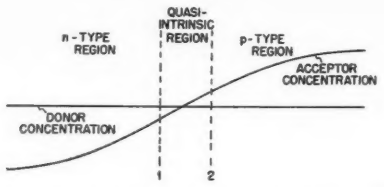

FIG. 1. Impurity distribution in n-p transition region.

ously into the acceptors, completely filling them.[3] Since the net donor concentration remains high, the material is n-type. To the right of line 2, all of the donors are emptied of electrons by spontaneous transitions to the acceptors, but since the net acceptor concentration is high, the material is p-type.[3] Between lines 1 and 2, the net impurity concentration is either zero or extremely small, and this transition region behaves essentially as an intrinsic semiconductor. The thickness of this quasi-intrinsic region increases with temperature because of the tendency of the Fermi level to merge with the intrinsic line[4] at high temperatures. It is also larger the more gradually the concentration of p-type impurity varies with distance in the transition region. Thus, in general, a quasi-intrinsic region is to be expected, the thickness of which may vary widely, depending upon the chemical and heat treatments employed and upon the operating temperature of the photocell. Moreover, the equilibrium condition that the Fermi level be everywhere the same requires transfer of electrons from the n-type region to the intrinsic region and from the intrinsic region to the p-type region. Thus, space charges are set up which correspond to potential barriers for the passage of charge carriers. The situation is illustrated by the energy level diagrams of

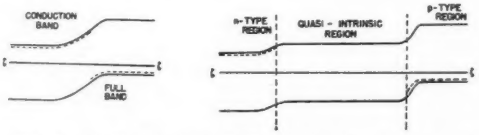

FIG. 2. *Left*, energy level diagram for sharp n-p transition. *Right*, energy level diagram for gradual n-p transition.

Fig. 2 which show two limiting cases, one where the thickness of the quasi-intrinsic region is zero (left) and one where it is large (right) as compared to the thickness of the space charge region. Although intermediate cases are of great interest, we shall for simplicity discuss only these limiting ones.

[3] An alternative possibility, having essentially the same consequences, is the mutual annihilation of donors and acceptors by recombination.

[4] By the intrinsic line is meant the line showing the variation of the Fermi level with temperature in a model comprising only a full band and a conduction band.

Case a—Sharp n-p *Transition.* (*Fig. 2, left*). In a perfectly sharp contact between n- and p-type regions, the establishment of equilibrium requires that electrons be transferred from the n- to the p-type material in the neighborhood of the contact. This creates a positive space charge in the n-type region and a negative space charge in the p-type region, corresponding to a variation of potential which, in the present instance, is continuous across the plane of contact and which obeys Poisson's equation in both regions. The height of the (rectifying) potential

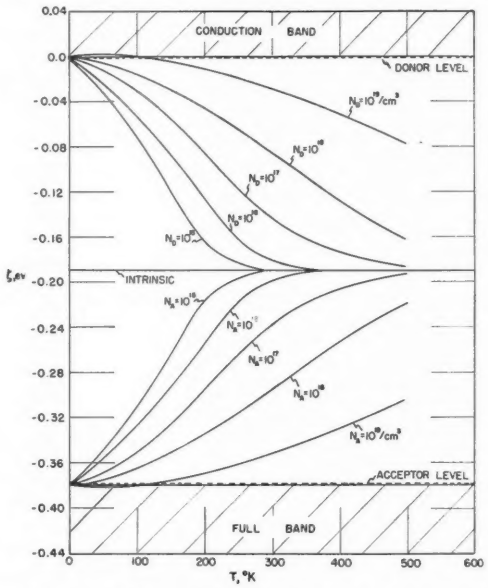

FIG. 3. Variation of Fermi level with temperature and impurity content in lead sulfide. Separation between full and conduction bands, 0.38 ev. Each impurity level is taken to be 0.001 ev from the nearest band and the effective masses of electrons and holes are taken as equal. The curves in the upper portion of the figure represent the behavior in n-type material of varying donor concentrations; the curves in the lower portion of the figure are the corresponding ones for p-type material.

barrier so created is equal to the difference in the Fermi level positions that would obtain if the n- and p-type regions were separated. This height can vary from zero (high temperatures, low impurity content) to about the energy separation between the bands (low temperatures, high impurity content), as may be seen from the calculated values of the Fermi level for PbS (see Fig. 3). With reasonable impurity content (about 10^{17}–10^{19}/cm^3) the resistance of such a potential barrier can greatly exceed the resistance of an impurity semiconductor of comparable thickness.

On exposure to steady illumination, electrons are excited from the full band to the conduction band

everywhere throughout the material. In both the *n*- and *p*-type regions far from the plane of contact, the electrons and positive holes created optically disappear so rapidly by recombination with the thermally produced fixed positive charges and electrons that the net increase in charge carrier density is extremely small. However, electrons and holes produced in the space charge region are rapidly separated by the strong electric field; electrons are drawn into the *n*-type region and partially neutralize the positive space charge, whereas the holes are drawn into the *p*-type region and partially neutralize the negative space charge. Consequently, the height of the space charge barrier and the corresponding d-c resistance are lowered. It will be noted that for each pair of charge carriers created optically and separated in the space charge region (photovoltaic effect) many charge carrier pairs can pass over the barrier (photoconductive effect). On removing the illumination, the system will spontaneously return to its equilibrium state in the dark with great rapidity by thermionic emission over the barrier of the excess charge.

The following behavior is expected of a photocell which may be approximated by a large number of sharp barriers of the type just described, shunted by thin well-conducting threads of *n*- or *p*-type material. The d-c resistance will appear to be ohmic and will be determined at high temperatures by the barriers and at low temperatures by the thin conducting threads. The d-c resistance will be considerably higher than the a-c resistance at high frequencies; the former will be appreciably lowered by radiation but not the latter. The photoconductivity can be shown to be a linear function of the intensity of radiation up to very high levels. The response time will probably be determined by the product of resistance and capacitance of the photocell.

Case b—Gradual n-p *Transition.* (*Fig. 2, right*). If the quasi-intrinsic region is much thicker than the space charge region, the potential barrier becomes split into two halves. Electrons and holes need only surmount the smaller barriers in order to recombine with each other. Under these circumstances the barrier resistances will nearly always be negligible with respect to the resistance of the quasi-intrinsic region and the properties of the latter will dominate.

Under steady illumination electrons and holes created optically in the quasi-intrinsic region recombine with each other and with the thermally released carriers until the rates of formation and recombination of charge carriers are equal. In the steady state a net increase in the charge carrier density and a corresponding decrease in resistance result. If the density of thermally released carriers is sufficiently small (large band separation, low temperature), the recombination rate will be low and the average lifetime of the "extra" carriers will be long. For sufficiently long lifetime, the number of charges flowing through the layer may greatly exceed the number created optically.

The following behavior is expected of a photocell which may be approximated by a large number of diffuse barriers of this type, shunted by thin threads of well-conducting material. The d-c resistance and the a-c resistance at high frequencies will be the same and both will be equally affected by radiation. The resistance-temperature behavior will be similar to that of a homogeneous intrinsic semiconductor containing impurities. The photoconductivity will be a nonlinear function of the intensity of radiation, following the bimolecular recombination law. The response time will be determined by either the recombination relaxation time or by the *RC* time constant, whichever is the longer.

The preceding discussion has stressed the extreme differences in properties resulting in two limiting cases. Obviously all shades of intermediate behavior are possible in actual photocells—for example, appreciable barrier contribution to the d-c resistance and nonlinearity with radiation intensity. There is evidence (*5, 1*) that some of the PbS cells which have been studied may approximate the sharp transition case. On the other hand, the nonlinear response to radiation which has been observed (*5, 6, 10*) in Tl_2S and in other PbS and PbTe cells indicates more gradual *n-p* transitions in these layers. The a-c resistance-temperature-illumination data of Chasmar (*1*) may perhaps be understood on the basis of barriers in which a relatively thin quasi-intrinsic region at low temperatures becomes thicker at higher temperatures.

Independently of the thickness of the quasi-intrinsic region, the general picture outlined here is capable of explaining a number of additional observations (*5–9*), e.g. the sensitizing role of oxygen or of the electronegative constituent, the requirement for high photosensitivity that both *n*- and *p*-type impurities be present simultaneously, the change in sign of the thermal emf coefficient with "oxidation," the correlation of maximum photosensitivity (expressed as $\frac{\Delta I}{I_d}$) with minimum conductivity, increase in photosensitivity with a decrease in temperature, quantum yields exceeding unity, and the occurrence of photo-emf's varying in magnitude and sign from point to point in the layer.

A detailed account will be published at the completion of an experimental program which has been in progress in this laboratory for some time.

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Technical Papers

Hemolytic Activity of Some Nonionic Surface-active Agents

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For a long time it has been known that surface-active agents, as exemplified by the soaps, possess marked hemolytic activity. Recent studies using synthetic anionic surface-active agents have confirmed these observations and demonstrated that the cytolytic efficiency of a homologous series of these compounds is dependent upon their carbon chain length. In discussion of these observations, emphasis has been placed upon correlation of the cytolytic power of these compounds to their surface activity (*3*) and upon complex formation, based upon electrostatic interaction, between the anionic surface-active agents and lipid, lipoprotein, and protein components of the red blood cell ultrastructure (*6*).

It is desirable to report upon the hemolytic activity of certain nonionic surface-active compounds at this time, both because of its pertinence to any consideration of the mechanism of these cytolytic effects and because of the practical importance of having available surface-active agents with desirable physical properties but largely devoid of such deleterious biological effects as hemolysis and toxicity.

This report will be confined primarily to a series of nonionic polymeric surface-active agents[1] based upon alkyl phenols made water-soluble by interaction with an alkylene oxide.[2] The alkyl-substituted phenol represents the hydrophobic portion of the molecule, while the ether-alcohol groups are the hydrophilic portion. The hemolysis studies utilized a 5% suspension of washed sheep red cells made up in 0.16M NaCl + 0.015M phosphate, buffered at pH 7.4. Hemolysis was studied by mixing 0.2 ml of the 5% sheep red cell suspension with 4.5 ml of buffered NaCl to which the desired amount of the surface-active agent had been added. This mixture is translucent, due to the scattering of light by the intact erythrocytes, but upon hemolysis it becomes transparent. The time required to achieve hemolysis of 75% of the cells has been used as an end point and was determined by visual comparison with a standard (*4*). Twofold dilutions of the surface-active agents were used and the time for hemolysis was plotted against the concentration of these compounds. From these plots the concentration per ml of surface active agent necessary for an hemolysis time of 100 min was estimated and used as a basis of comparison. Surface tensions at 25° C were determined with the duNouy tensiometer, previously standardized against H_2O and benzene.

It will be seen (Table 1) that two of the nonionic compounds, Tritons WR-1352 and A-20, are distinguished from the other surface-active agents listed in being nonhemolytic. This is evident at concentration levels approximately 1,000-fold greater than is necessary to produce hemolysis with the other surface-active compounds. These two compounds, which in high concentration are nonhemolytic to sheep cells, evidence this innocuousness at concentration levels at which they depress the surface tension of H_2O from a control value of 72 to 33 or 42 dynes per cm. In contrast, the other nonionic and ionic surface-active agents in Table 1 are hemolytic at concentration levels which depress the surface tension of their aqueous solutions to 37 dynes per cm for the least hemolytic and to 68 dynes per cm for the most hemolytic compound. Thus, alteration of the physical properties of the solution as exemplified by measurements of surface tension can in no way suffice to explain the presence or lack of hemolytic activity of surface-active agents. Both anionic and cationic surface-active agents have been shown to form saltlike, stoichiometric complexes with proteins and to cause their denaturation (*2*, *7*). Nonionic compounds, on the other hand, do not possess strong polar groups and are thus unable to enter into electrostatic interaction with proteins, as is evident from studies of electrophoresis (*5*), precipitation (*1*, *2*), and alteration of biological activity (*1*, *2*). This means that the hemolytic activity of those nonionic compounds which evidence this property must be based upon nonelectro-

[1] The Triton compounds, as listed in Table 1, were made available through the courtesy of the Rohm and Haas Company.

[2] Bock, L. H. and Rainey, J. L. 1948 U. S. Patent 2,454,541.

static interactions with cellular components involving van der Waals' forces or hydrogen bonding. The degree of polymerization may be an important factor in determining the hemolytic activity of these nonionic surface-active agents with the most highly polymerized compounds evidencing the least hemolytic activity. However, an insufficient range of compounds was available to establish this point.

TABLE 1

HEMOLYTIC ACTIVITY OF SELECTED SURFACE-ACTIVE AGENTS

Surface-active agent	Concentration (μg/ml) for 100-min hemolysis time	Surface tension (dynes/cm) at that concentration
Nonionic compounds		
Triton WR-1352	>10,000	(42)*
Triton A-20	>10,000	(33)
Triton M-3619	33	37
Triton N-100	30	40
Triton X-155	10	51
Triton WR-1363	10	40
Triton WR-1360	6	40
Triton WR-1364	4	57
Anionic compounds		
Dioctyl sodium sulfosuccinate (Aerosol OT)	20	52
Sodium lauryl sulfate (Duponol WA)	17	60
3,9-Diethyltridecanol-6 sodium sulfate (Tergitol 7)	5	57
Cationic compounds		
Cetyl dimethyl benzyl ammonium chloride	9	57
Cetyl pyridinium chloride (Ceepryn)	4	67
Cetyl trimethyl ammonium bromide (CTAB)	4	68

* Values in parentheses were measured at a concentration of 10,000 μg/ml.

It is of interest to record, in addition, that the two compounds observed to have such low hemolytic activity also displayed a low toxicity. Upon intraperitoneal injection into mice, both Tritons WR-1352 and A-20 had an LD_{50} (10-day observation period) of more than 2,500 mg per kg body wt. No higher concentrations were used, due to the viscosity of these compounds at this level. This is in contrast with the LD_{50}'s of the other compounds listed in Table 1, which ranged from 1 to 50 mg per kg for the cationic, 70 to 100 for the anionic, and 100 to 300 for the other nonionic compounds.

In summary, attention has been called to two nonionic surface-active agents capable of altering the physical properties of solutions but largely devoid of such deleterious biological effects as hemolytic activity and toxicity.

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The Inhibitory Effect of Three Antihistaminic Compounds on the Growth of Fungi Pathogenic for Man

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Recent observation in this laboratory revealed that several cases of *tinea pedis* (athlete's foot) responded dramatically to applications of a cream containing 2% pyribenzamine. This observation suggested that the antihistamines should be assayed for inhibitory activity against the pathogenic fungi. The following studies were conducted to determine whether the effect noted was solely against allergic manifestations incited by the etiologic agent (*4*) or whether such compounds possessed fungistatic or fungicidal properties as well.

Three crystalline antihistaminic compounds selected for investigation were pyribenzamine hydrochloride (Ciba),[1] antistine hydrochloride (Ciba),[2] and di-phenyl-pyraline (Nopco).[3] Final concentrations of 0.1, 0.25, 0.5, 0.75, and 1.0 mg/ml of the freely soluble drugs were prepared in Mycophil broth (Baltimore Biological Laboratory). These were dispensed to tubes in 5.0-ml quantities and autoclaved at 15 lb for 15 min. After sterilization the pH of the control broths as well as those containing the varying concentrations of di-phenyl-pyraline and antistine was 6.65; those containing pyribenzamine were pH 6.3.

The dermatophytic species tested included four strains of *Microsporum*, eight of *Trichophyton* and seven of *Epidermophyton floccosum*. Single strains of *Candida albicans, Cryptococcus neoformans, Histoplasma capsulatum*, and *Blastomyces dermatitidis*, causative agents of systemic mycoses, were also employed in the study. With the exception of three organisms (*T. ferrugineum, C. albicans*, and *C. neoformans*) all strains had been isolated from human lesions within the previous six months.

The test media containing the antihistamines and the control media without antihistamine compounds were inoculated with ½-ml amounts of organism suspension prepared according to the method outlined in a previous publication from this laboratory (*1*). All cultures were incubated at 28° C and examined for comparative growth at three-day intervals for a period of two weeks.

[1] N,N-dimethyl-N'-benzyl-N'-(α-pyridyl)-ethylenediamine monohydrochloride.
[2] 2N-benzyl-N-phenyl-aminomethyl-imidazoline hydrochloride.
[3] 1-Methyl-piperidyl-4-benzhydryl ether.

TABLE 1

INHIBITORY EFFECT *in Vitro* OF THREE ANTIHISTAMINIC COMPOUNDS ON RECENTLY ISOLATED STRAINS OF PATHOGENIC FUNGI

Organism	No. strains tested	Compounds					
		Di-phenyl-pyraline		Antistine		Pyribenzamine	
		Negative*	Restricted†	Negative*	Restricted†	Negative*	Restricted†
Dermatophytes:							
Trichophyton mentagrophytes	2	0.50	0.10	1.00	0.25	>1.00	0.25
" *rubrum*	5	0.50	0.10	0.75	0.25	>1.00	0.25
" *ferrugineum*	1	0.25	0.10	0.50	0.10	0.50	0.10
Microsporum gypseum	3	0.50	0.10	1.00	0.50	>1.00	0.25
" *lanosum*	1	0.50	0.10	1.00	0.50	>1.00	0.25
Epidermophyton floccosum	7	0.50	0.10	0.50	0.25	0.75	0.25
Systemic fungi:							
Histoplasma capsulatum	1	0.25	0.10	0.75	0.25	0.50	0.25
Blastomyces dermatitidis	1	0.50	0.10	0.50	0.10	>1.00	0.50
Cryptococcus neoformans	1	0.50	0.10	0.25	0.25	1.00	1.00
Candida (Monilia) albicans	1	>1.00	...	1.00	0.75	>1.00	...

* Mg/ml of drug concentration completely inhibiting growth.

† Mg/ml of drug concentration that restricted growth to approximately 30%–40% of growth in control containing no antihistamine.

The results shown in Table 1 illustrate the comparative inhibitory effect exhibited by the three compounds following the two-week period of incubation. Growth was markedly restricted at 0.25-mg/ml concentrations of diphenyl-pyraline and completely inhibited, macroscopically, at 0.5 mg/ml with all strains tested except *C. albicans*. The effective concentrations of antistine varied with the species tested and ranged from 0.5 to 1.0 mg/ml. Pyribenzamine was the least effective. Concentrations of 1.0 mg/ml failed to inhibit the growth of 13 of the 23 test organisms.

To determine the effect of hydrogen ion concentration on the inhibitory activity of the compounds, two sets of media were adjusted to pH 5.0 and 8.0 respectively. The subsequent addition of the test drugs did not alter the pH level of either medium. Each set was inoculated with three strains representative of the dermatophytic genera. The results obtained at pH 8.0 with the antistine and di-phenyl-pyraline compounds were similar to those shown in Table 1. Pyribenzamine, however, showed an improvement in its inhibitory capacity in that a concentration of 0.75 mg/ml was as effective at pH 8.0 as a > 1.0 mg/ml concentration at pH 6.3. Conversely, in media adjusted to pH 5.0, 1.0 mg/ml concentrations of each of the three compounds failed to inhibit growth of the organisms. The compounds are heat stable in that no detectable difference in inhibitory activity could be demonstrated between autoclaved and Seitz-filtered solutions of the drugs.

The efficacy of many reportedly inhibitory agents has been shown to be greatly reduced, and in many instances completely negated by the presence of serum in the test medium (*2, 3*). A further study was conducted employing the penicylinder method of assay (*2*) and Sabouraud's dextrose agar containing horse serum in a final concentration of 10%. Two sets of media, one adjusted to pH 5.0 and the other to pH 7.0, were prepared and autoclaved at 15 lb for 15 min. The media were cooled to 45° C for the addition of horse serum, and then were distributed in Petri dishes in 20-ml quantities and allowed to solidify. Aqueous solutions of the drugs were added to the penicylinders on plates streaked with a ten-day-old culture of *T. mentagrophytes*. After ten days' incubation at 28° C, zones of complete inhibition, measuring 4, 3, and 1.5 cm in diam were obtained at both pH levels with 2.0-, 1.0- and 0.5-mg/ml concentrations of diphenyl-pyraline (see Fig. 1). The inhibitory activity of

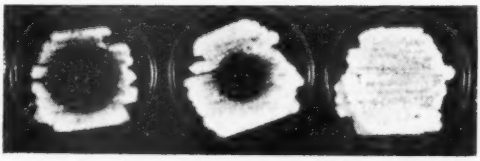

FIG. 1. Inhibitory activity of di-phenyl-pyraline against *Trichophyton mentagrophytes* cultured in Sabouraud's agar (pH 7.0) containing horse serum in a final concentration of 10%. The first penicylinder on the left contained 2.0 mg/ml of the drug, the second 1.0 mg/ml. The third is the organism control.

pyribenzamine against the growth of the test organism on serum agar adjusted to pH 7.0 resulted in zones of complete inhibition measuring 2.5 and 2.0 cm in diam with 2.0- and 1.0-mg/ml concentrations. A 1.5-cm zone was obtained with 0.5 mg/ml but inhibition was not complete. When tested on serum agar adjusted to pH 5.0, the 2.0-mg/ml concentration, showing an inhibitory zone of 1.5 cm, was the lowest level at which this drug was effective. Antistine, which appeared to be inhibitory in the absence of serum (Table 1), failed to inhibit growth at either pH level when serum was incorporated in the medium.

The growths of four systemic species (*C. neoformans* and yeast phase cultures of *H. capsulatum*, *B. dermati-*

tidis, and *Sporotrichum schenckii*) incubated on the horse serum agar (pH 7.0) at 37° C also were inhibited by 1.0-mg/ml concentrations of di-phenyl-pyraline and pyribenzamine. The growth of *C. albicans* was not affected by either drug.

Results obtained from these preliminary studies suggest that both di-phenyl-pyraline and pyribenzamine possess properties which are inhibitory to pathogenic fungus species and that their activities, therefore, are not limited to the alleviation of allergic manifestations incited by these organisms. The results also suggest that further clinical study is imperative to determine the effectiveness of these drugs *in vivo*.

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Triphenyltetrazolium Chloride in Tissue Culture[1]

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A number of reports have recently appeared in the literature describing a tetrazolium salt (2,3,5-triphenyltetrazolium chloride) as a possible indicator of viability of plant and animal tissues. Lakon (*3*), Cottrell (*1*), and Porter, Durell, and Romm (*4*) have used this compound to test the viability of seeds and wood cuttings, and Straus, Cheronis, and Straus (*6*) employed this salt to demonstrate reducing enzyme systems in living normal and neoplastic mammalian tissues.

In studies of the nucleic acids and of the effect of folic acid and its analogues on tissue cultures, it is occasionally important to determine cytologically the number of living cells present in a particular culture. Since the cytoplasm and nuclei of living cells do not stain with any of the vital dyes, and dead cells stain only diffusely, the use of tetrazolium as an indicator of cellular viability suggested itself. It is the purpose of this paper to report the failure of 2,3,5-triphenyltetrazolium chloride as an indicator of cell viability of tissue grown *in vitro*.

The method employed in testing this compound consisted of growing chick-heart fibroblasts under perforated cellophane (*2*) in a medium composed of equal parts of human fetal (umbilical cord) serum and Simms salt-diluted ultrafiltrate (*5*). After 72 hr, when sufficient migration and outgrowth of fibroblasts had occurred, the cultures were placed in a 1% solution of the tetrazolium salt in 0.9% NaCl. They were then examined grossly and microscopically, every 20 min for 6 hr, for evidence of reduction of the colorless tetrazolium to the red insoluble formazan. In none of the 16 cultures tested was there any observed reduction of the salt. Cultures left in this solution for 48 hr also gave negative results.

The failure of whole, uninjured, rapidly growing embryonal cells to reduce tetrazolium chloride indicates that this compound is not necessarily a measure of cellular viability. The action of tetrazolium chloride depends on combination with dehydrogenases which cause a reduction of the dye to its colored form. Apparently the failure of the compound to penetrate through the living cellular membranes is responsible for the negative results obtained.

[1] Supported in part by a grant from the Iowa Division, American Cancer Society.

[2] Research Fellow, American College of Physicians, 1949–50.

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A Modification of the Hardy-Weinberg Law

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The Hardy-Weinberg law, as it is customarily specified or understood, applies to populations which are indefinitely large, which are panmictic, and in which gene frequencies are the same in both sexes. If, in addition to these conditions, gene frequencies are constant, genotype frequencies will also be constant through succeeding generations (*2–6*).

Whether gene frequencies are constant or not, the primary distribution (*primary* being used in the same sense as applied to sex ratio) of mean genotype frequencies for two alleles A and a, with respective frequencies p and q ($q = 1 - p$), is written $p^2AA : 2pqAa : q^2aa$ when A and a are autosomal and ♀♀ ($p^2AA : 2pqAa : q^2aa$) + ♂♂ ($pAY : qaY$) when they are sex-linked. But the frequency of one of the two alleles, say q, may be very small, and when it is sufficiently small it is evident that generations will occur in which homozygous recessives will not be produced; regardless of the smallness of q, the term q^2 then represents the probability of occurrence of genotype aa, but not its frequency, which of course is *0*. Under this condition the genotypic distribution for a pair of autosomal genes A, a becomes $(p-q)AA : 2qAa$, which provisionally may be called a limiting distribution. This can readily be seen, since under panmixis the proportions of pA and qa that recombine will be equal and will

be limited by the lesser of the two gene frequencies, in this case q. Hence the frequency of Aa is $2q$, while that of AA is $1-2q=p-q$. When sex-linkage is involved the distribution becomes, obviously, ♀♀ $(p\overline{-q}AA:2qAa)$ + ♂♂ $(pAY:qaY)$, and the ratio of female carriers to male exhibitors is $2q:q=2:1$, rather than $2pq:q=2p:1$ as in the Hardy-Weinberg distribution.

Application of the Hardy-Weinberg law to determining primary distribution of genotype frequencies requires not only that the population be indefinitely large, panmictic, and with gene frequencies equal in both sexes, but also that the relation between the population number N (breeding population) and the gene frequency q be such that $q \geqq N^{-0.5}$. Whether a Hardy-Weinberg or a "limiting" distribution obtains actually depends upon this relation between q and N, rather than upon the absolute size of either (Dahlberg [1] and Hogben [3] have discussed a similar though not identical situation). It follows that, on the average, the point in the possible values of q at and above which the Hardy-Weinberg distribution applies, and below which it does not, is given by log $q=0.5$ colog N. When log $q<0.5$ colog N, genotype frequencies take the form of a limiting distribution, the Hardy-Weinberg distribution then being a probability distribution but not a frequency distribution, with respect to the pertinent genotypes.

The consequences of this relation between population size and gene frequency are at present being worked out for a number of different genetic conditions.

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A Simple Pulsating Perfusion Apparatus

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Descriptions of a number of perfusion devices are available in the literature. Many of these are highly complex, adapted to special purposes, or inefficient. We have found that a very satisfactory perfusion apparatus can be simply prepared using a Sterling Automatic Pipette.

The most important parts of a pulsating perfusion device are the valves to control the direction of flow of the blood, and a mechanism to simulate the pumping of the heart. The delivery mechanism of the automatic pipette effectively embodies both these features. The pipette used by us was a Sterling Automatic Pipette, Model 4-3 M (Ivan Sorvall, New York). The amount of perfusate delivered per stroke can be regulated from 0.5 ml to 3.0 ml by adjustment of the stroke regulator. In order to control the rate of pulsation we attached the delivery mechanism of the pipette, by means of a reduction gear, to a variable speed motor. We have found, however, that the perfusion pressure can be adequately adjusted by means of the stroke regulator when delivery rate is 50 strokes per min.

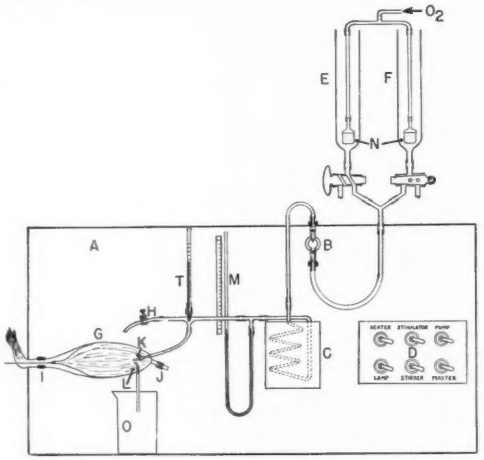

FIG. 1.

Fig. 1 presents diagrammatically a successful adaptation of this pump for the perfusion of an isolated dog hind leg, using defibrinated blood. The leg was prepared as described by Huston, Martin, and Dille (*1*). The leg was kept in good condition for several hours during investigations of the effects of certain drugs on the somatic neuromyal junction.

The tubing and clamps for the leg are attached to a perpendicular board, A. The motor for the pump and the apparatus for the constant temperature water bath are placed behind the board. Just the head of the pipette, B, and a small chamber of the water bath, C, protrude through holes in the board. In this way the work area is kept free of apparatus. The electrical equipment is controlled by switches on plate D.

The blood is stored in two reservoirs, E and F; one is for normal and the other for experimental blood. Oxygenation is accomplished by bubbling oxygen through small Mandler-type filters in the reservoirs. A two-way stopcock at the bottom of each reservoir provides a bypass.

The blood passes from the reservoir to the pump, B, and to the leg, G, through a coil in a constant temperature water bath, C. The perfusion pressure is recorded on a manometer, M; and the temperature on the thermometer, T. H is a bypass for rapid withdrawal of blood from the system.

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Calorimetric Method for the Determination of the Surface Energy of a Brittle Crystalline Solid

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Measurement of the surface energy existing at a solid-gas interface has presented experimenters with a difficult problem because of the rigidity of the interface. The surface energy of a gas-liquid interface can be determined with some precision by noting the energy necessary to deform the interface by a known amount. The problem of solid surface energies has received attention from a number of research workers; one of the earliest of these, Gibbs (*3*), defined the surface energy of a solid as that energy necessary to produce a unit of new surface on the solid. The Gibbs-Thomson relationship, an outgrowth of his work and others', can be used in the thermodynamic approximation of solid surface energies. This equation gives a relationship between particle size and vapor pressure for small particles of a solid:

$$RT \ln X_s/X = 2M\gamma/rd$$

where M is the mol wt of a solid, γ is the free surface energy, r is the radius of curvature of the small particle, d is the density of the solid, X_s is the higher vapor pressure of particles of radius r, and X is the normal vapor pressure of large particles of the solid.

Centnerszwer and Krustinsons (*2*) used a modified form of this relationship to calculate the surface tensions of oxide and carbonate metallic salts, such as mercuric oxide and silver carbonate. Measurement of the vapor pressures and particle radii of these solids allowed calculations of surface tensions ranging from 3,000 to over 100,000 dynes per cm. Other workers, in general, found values of a lower order of magnitude for the surface energies, or tensions, of solids. Values obtained experimentally by a number of methods indicate that the order of magnitude of solid surface energies may be between 100 and 1000 ergs/cm². Most of these experiments were performed on soluble ionic solids of a rather soft nature, notably halide salts. No universally acceptable experimental method has yet been published, and agreement as to the order of magnitude of these important physical constants has not been achieved among research workers.

The lack of adequate data on the surface energies of minerals has been a handicap felt particularly by workers in the fields of comminution and froth flotation. Estimates of doubtful validity have placed the surface energy of quartz, a common industrial mineral, at about 1,000 ergs/cm². Use of this figure in the calculation of the efficiencies of industrial ball mills has yielded remarkably low results, on the order of 1%. Gross and Zimmerly (*4*) used a drop-weight method for crushing quartz and an HF acid dissolution method for estimating the surface produced, and found that some 56,000 ergs of work was necessary to produce a square centimeter of new quartz surface. No heat loss measurements were made during their experiments, which were primarily designed to measure the crushing resistance of various minerals.

When a brittle crystalline solid is comminuted, the particle size is reduced and the surface is increased. Energy is consumed in the actual rupture of ionic and atomic bonds, in the production of slippage on crystal planes, in the production of twins and other atomic rearrangements, and in the production of heat by internal friction below the elastic limit. The energy of slip, twinning, and bond rupture is stored in the system as potential energy and heat energy is liberated from the crystalline system by conduction and radiation. The energy of bond rupture is termed the surface energy and is probably very large as compared with the energy of slip and twinning, particularly in a hard substance such as quartz. Therefore, if the comminution process were carried out inside a calorimeter, the total heat energy liberated by both friction in the comminuting medium and in the crystalline solid could be measured. Furthermore, an accurate determination of the energy input to comminution would permit calculation of the net energy going to the creation of new surface, that is, to the rupturing of atomic bonds. Estimation of the net new surface produced by an increment of energy is possible by the BET (*1*) method of gas adsorption at low temperatures. From this information, calculation of the specific surface energy of the comminuted solid is possible. The method makes no provision for the effect of crystal slip and twinning, or for the adsorption of gases that may be present in the comminuting calorimeter. The energy effect of these should be small.

A calorimeter was constructed to experiment with this proposed method of determining the total surface energy of crystalline solids. This calorimeter consists of a brass chamber 3 in. in diam suspended inside a stainless steel water jacket, so that it can be completely surrounded by water except for two brass suspension bearings affixed to each end. A Beckmann thermometer was inserted into the water bath, and could be read to the nearest hundredth of a degree Centigrade and estimated to one-thousandth of a degree. The brass chamber was filled with about 200 g of the crystalline solid and 3 kg of chilled steel shot. Revolution of the whole assembly on its longitudinal axis, suspended on ball bearings, caused tumbling of the charge mass and comminution of the brittle solid. A calibrated spring and sprocket arrangement was used to turn the calorimeter and gave the net energy input to the tumbling mass with good accuracy. The thermometer revolved with the calorimeter without affecting its calibration. The whole assembly was placed inside a wooden box whose air temperature was controlled at 20°–25° C ± 0.1° C by compressed air, a cooling coil, and a thermoregulator. Heat loss from the calorimeter shell was determined and formed the basis of a heat loss curve so that this factor was always known. The calorimeter constant was derived by use of the heat of solution of NaOH in water. Calibration of the whole assembly was achieved by using only the steel shot in

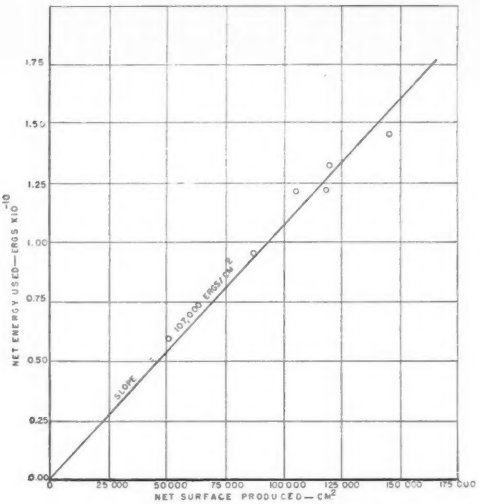

FIG. 1. Surface energy of quartz sand.

the chamber. Under these conditions, the kinetic energy input balanced the energy output as heat when the calorimeter was revolved for a short length of time. No breakage occurred under these conditions, and all of the energy input became heat energy through friction of the tumbling mass. However, when a brittle material such as quartz was added to the chamber and was comminuted, the energy output was about 10%–20% lower than the energy input. By the reasoning already outlined, this difference was considered to remain on the brittle material as surface energy.

The total surface on the brittle solid was measured both before comminution and after comminution by the rather well-known method of BET adsorption isotherms, using CO_2 gas as the adsorbate. The net surface produced during the comminution was thus obtained by subtraction and, divided into the net energy difference, gave the specific surface energy of the brittle crystalline solid.

The calorimeter was used to derive the surface energy of quartz by making a series of determinations on a glass sand made up of quartz grains. The net energy consumption—that is, the energy to create new surface—was plotted against the net surface produced (Fig. 1). A straight line is seen to average the six points determined and, moreover, to pass through the origin of the plot as it should. The slope of this line is considered to give the average total surface energy of the quartz sand. It is 107,000 ergs/cm². The deviations of the individual points from the straight line are not large. The order of magnitude of this surface energy figure for quartz is not seriously in conflict with the figures mentioned earlier in this article, and seems to agree in a qualitative way with the difference in hardness of a substance like quartz and a substance like mercury with a surface energy of approximately 473 ergs/cm² at room temperature.

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Some Derivatives of Diphenyldisulfide with Antispirochetal Activity[1]

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Among the few synthetic and natural disulfides (gliotoxin) which have been studied chemotherapeutically, no substances of therapeutic importance have been found. This may be the result of the low activity of these substances or of their unfavorable chemotherapeutic ratio. Research on bis(4-aminophenyl)disulfide makes it seem possible that the disulfides constitute a class of chemotherapeutic agents distinct from the sulfonamide drugs, and active through a different mechanism, which has not yet been defined (*4*).

For some time two of us (P. P. and L. R., *5*) have focused our attention on bis(2-aminophenyl)disulfide and its related compounds. McDonagh (*1, 2*) recognized the activity of bis(2-aminophenyl)disulfide against *Spirochaeta pallida*; we have since found that this substance is also active against *Borrelia recurrentis* (*3, 6*).

In view of the antispirochetal activity of bis(2-aminophenyl)disulfide, we thought it would be interesting to see whether correlations analogous to those existing between *p*-amino-substituted disulfides and sulfonamides in *coccus* infection would hold good also for spirochetal infection in the series of *o*-amino derivatives. For this purpose, a series of *o*-amino sulfamides was prepared, that is: 2-aminobenzenesulfonamide, 2-(2-aminobenzenesulfamido)-pyridine, 2-(2-aminobenzenesulfamido)-4-methylthiazole, and 2-(2-aminobenzenesulfamido)benzenesulfamide, in order to see if these substances would show antispirochetal activity greater than that already observed in bis(2-aminophenyl)disulfide.

Research on the activity of these compounds against *Spirochaeta hispanica* and *Treponema brucei* in mice was performed by Prof. D. Bovet at l'Institut Pasteur, Paris, and has given completely negative results (*6, 7*). This confirms the distinction between the class of disulfides and that of the sulfonamides as chemotherapeutic agents.

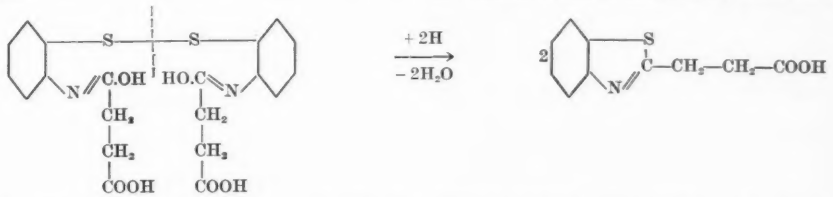
Among the derivatives of bis(2-aminophenyl)disulfide previously synthesized by us, one of the most interesting was the *N*-disuccinyl derivative (*3, 6 7*). Although its average lethal dose (13 mg per 20-g mouse) is only a

[1] Read at the First International Congress of Biochemistry (Section X), Cambridge, August 19–25, 1949.

little larger than that of bis(2-aminophenyl)disulfide (10 mg per 20-g mouse), the succinyl derivative is tolerated better at therapeutic doses and is clearly superior in its chemotherapeutic activity against *Borr. recurrentis*. In many experiments on *Borrelia*-infected mice, after a single injection of 4 mg of the succinyl derivative, about 50% were completely cured, and in the rest the infection took a far less serious course. This was deduced from the decreased number of organisms in the blood stream.

It is important to note that the molecular weight of the succinyl derivative is almost double (492) that of the free amine (248) and consequently, at the same weight, the molar concentration of the succinyl derivative is about half that of the amine. We must also note that the free amine is fat-soluble and the succinyl derivative is water-soluble; this difference influences, of course, the absorption and elimination of the two substances.

Bis(2-succinylaminophenyl)disulfide, when reduced by H_2S, cysteine, or ferrous hydroxide, in an acid, neutral, or alkaline medium does not give the corresponding thiol; instead it gives benzothiazolpropionic acid (BTP) (mp 108°–109° C; methyl ester 57°–59° C), which is immediately formed from the thiol by elimination of a molecule of water.



Since the same transformation might occur *in vivo*, it seemed possible that the activity of the compound was not due to the disulfide group, but to the benzothiazole derivative which arises from it.[2] This possibility could be investigated either by studying the action of the succinyl derivative and of benzothiazolpropionic acid on a certain number of microorganisms, or by examining the action of derivatives, substituted in such a way as to prevent their transformation into benzothiazoles. For a substance which possesses such a property we have chosen the bis(2-methylaminophenyl)disulfide, mp 72°–73° C, which was prepared in good yield from asymmetric methylphenylthiocarbamide.

The succinyl derivative and benzothiazolpropionic acid were tested biologically by Dr. Nascimbene and Prof. Babudieri. We also thank Sir C. Harington, the director of the National Institute for Medical Research, Hampstead, London, for arranging for Dr. Fuller to study the activity of these two substances against *Streptococcus hemolyticus*, *Staphylococcus aureus*, and *Escherichia coli*.

Results, briefly, are as follows: Bis(2-succinylaminophenyl)disulfide (Na salt), besides being considerably active against experimental infection in mice with *Borrelia recurrentis* (*3*), is also somewhat active against *Leptospira ictero-haemorrhagiae in vitro*[3] (growth is considerably inhibited at a concentration of 1: 12,000, completely at 1: 6,000). It has a definite action against *Staphylococcus aureus*[4] and *Streptococcus hemolyticus*,[5] less definite against *Escherichia coli*[6] and *Eberthella typhosa*[7] and has no action against a paratubercular strain[8] (Babudieri, Fuller). It has no action against *T. brucei* in mice (Babudieri). Benzothiazolpropionic acid (Na salt), under the same conditions, is completely inactive against all the organisms and infections mentioned (Nascimbene, Babudieri, Fuller). Bis(2-methylaminophenyl)-disulfide[9] is very active against *Staphylococcus aureus* and *Streptococcus hemolyticus* (complete bacteriostasis at concentrations of 1: 20,000 and 1: 100,000, respectively. It has a similar activity against *Leptospira ictero-haemorrhagiae* (complete bacteriostasis at a concentration of 1: 200,000). There is also a slight effect on *T. brucei* so that when ten mice were infected with *T. brucei* and treated for 2 days successively with 10 mg of the product, only two mice died after 48 hr, two after 3 days, and six after 4 days, while all the control mice died before 48 hr. This proves that the chemotherapeutic activity of these compounds is due to the molecule of the disulfide as such, which probably interferes with some essential metabolite by oxidizing or keeping oxidized a substance which should be reduced.

Among the enzymes which might be inhibited by disulfides, we first thought of sulfydryl enzymes. Such enzymes are inhibited by *p*-chloromercuribenzoate, certain trivalent organic arsenicals, and iodoacetamide. It is known that the pyruvate-oxidase system belongs to this group of enzymes. Prof. R. A. Peters, director of the Department of Biochemistry, Oxford, has demonstrated the inhibitory activity of bis(2-succinylaminophenyl)disulfide on the pyruvate-oxidase system in pigeon brain tissue. The concentration at which the system is inhibited (0.5–1.0 mg/3 ml) is about that of the chemotherapeutic activity on *Borrelia recurrentis*.

It is concluded that among the aromatic disulfides,

[2] There might be competitive inhibition with some essential metabolite. It is well known that benzimidazole, isostere with benzothiazole, inhibits the action of adenine (*8*).

[3] Strain Zaan, in Korthof's medium.

[4] Strain Oxford, in broth.

[5] Strain 1BD, in broth.

[6] M. 3, in broth.

[7] V. 1, in broth.

[8] Strain Horn, in broth.

[9] The substance is soluble in oil and in alcohol-water. It has been dissolved in alcohol and the alcoholic solution (0.5%) added to the culture medium. We have proved that in this amount the added alcohol had no action on bacterial growth. *In vivo*, we used a 2% oil solution. The bis(2-methylaminophenyl)disulfide is less toxic (10 mg is well tolerated) than bis(2-aminophenyl)disulfide (lethal dose is 10 mg/20-g mouse).

there are substances possessing chemotherapeutic activity sufficient to justify a thoroughly systematic study. The activity against *Leptospira* is particularly interesting. It seems that the *N*-alkyl derivatives of the *o*-amino series, which are unable to form ring compounds, such as inactive benzothiazoles, may be more active and have less toxicity than the corresponding nonalkylated derivatives. This follows from the behavior of bis(2-methylaminophenyl) disulfide. The activity of these compounds is connected with their oxidizing action. The bis(2-acylaminophenyl) disulfides, owing to their capacity for irreversible reduction (following cyclization to benzothiazoles) may in some cases constitute useful agents for the study of certain enzymatic systems.

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New Method for Blood Pressure Recording

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During the last decade there has been an ever increasing interest in electrical transmission methods for accurate measurement and recording of intra-arterial pressure. A number of methods have been described, e.g., photoelectric (*9*) and piezoelectric (*5*, *6*) manometers, Clark reluctance manometer (Clark Pressure Capsule) (*7*), capacitance manometers (*1*, *10*), and inductive (*8*) and resistance (*2*, *4*) transmission methods.

In our investigations of the physiological effects on animals of high explosive blasts, we originally used a resistance-wire instrument (strain-gage) for the continuous recording of arterial blood pressure during the detonation (*3*). Since this method has several disadvantages, however, we have now developed an instrument in which the pressure variations are transmitted by a mechano-electronic transducer. So far as we know, this principle has not been used before in blood pressure recorders.

The instrument consists of a small pressure chamber with a thin silver membrane. The membrane acts directly upon the movable anode of the transducer tube (RCA 5734). The chamber and the short steel cannula which is inserted in the blood vessel are filled with a solution of 1% heparin in physiologic NaCl.

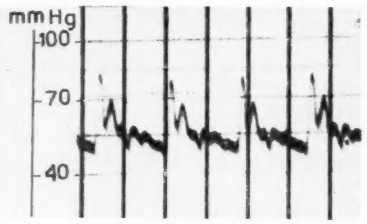

FIG. 1. A recording of the pressure in the carotid artery of a rabbit. The heavy vertical lines represent intervals of 1/10 sec. The curve is underdamped.

The transducer is connected to a pentode as a variable grid leak. The recording instrument (e.g., an oscillograph) is bridged in the anode circuit of the pentode. By using this way of coupling it is possible to make full use of the excellent frequency properties of the transducer. Another advantage is that the transducer has no other electric tension than the filament voltage and the grid voltage, which amounts to only a few volts.

The construction of the instrument is very simple and sturdy. Owing to the small dimensions of the transducer (length 20 mm, diam 8 mm) the whole instrument can be made very small and convenient. It requires only a slight amplification with one amplifier valve, or if the recording device is sensitive enough the amplification is not necessary at all. The instrument has a great range of frequencies and the phase displacement of the recordings is insignificant (Fig. 1). Owing to its low input impedance, the apparatus is quite insensitive to outside disturbances even if long feed lines must be used (as, for instance, in blasting experiments). The sensitivity of the instrument makes it possible to record fluctuations of pressure down to 1–2 mm of water. Supplied with a suitable membrane the apparatus can, therefore, be used even for recording venous pressure.

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Comments and Communications

Does Genetic Endowment Vary by Socioeconomic Group?

The preliminary publication in *Science* (1949, **110**, 201) of the chapter on "Selection and Eugenics" from Curt Stern's *Principles of Human Genetics* (San Francisco: W. H. Freeman, 1949) has given wide circulation to judgments which cannot go unchallenged if the interests of science and human welfare are to be served.

Curt Stern has done well to incorporate in this chapter some of the well-established criticisms of eugenics. However, in his discussion of the eugenic thesis that the intellectual genetic endowment of Western populations is in danger of decreasing because of differential fertility along class lines, he manifests conventional biases and pitches the authority of his science on the side of eugenic doctrine. He begins by acknowledging that "it is not possible, at the present time, to state with certainty whether different socioeconomic groups are genetically differentiated" (*Principles*, p. 514). However, when interpreting the divergent I.Q. scores of "own" and foster children grouped by occupational categories, he nevertheless contends that "it is hard to avoid the conclusion . . . that there *are* mean differences in the genetic endowment of the different socioeconomic groups" (p. 515). (Italics are in the original.) He makes repeated qualifications as he proceeds, but his discussion concludes that "it is likely that the present differential fertility of the different socioeconomic groups has a dysgenic effect in regard to intelligence" (p. 520).

Before pronouncing a crucial judgment of such importance and such great potential influence upon social and educational policy, the author should, one would hope, be careful to utilize only the most reliable data. The very contrary is true. Leahy's 1935 study of the comparison of I.Q.'s of "own" and foster children in homes of different occupational categories is selected from other like studies analyzed in Frederick Osborn's *Preface to Eugenics* (New York: Harper's, 1940), but Osborn's recognition that the study has limited applicability "in view of the small number of persons included in the present studies and the many weaknesses of the studies themselves" (p. 66), is ignored. Similarly, the table presenting the findings of Goodenough's study in 1928 of the I.Q.'s of 380 preschool children correlated with the occupation of their fathers is a fragment of a larger table derived from Osborn, but Curt Stern has paid no attention to the footnote warning in Osborn's table that testing for preschool children "is not so valid as for the school years" (p. 82). Curt Stern evidently felt that his case would be stronger if he showed that his generalization applied to the Soviet Union as well as to the United States. In his preliminary publication of the chapter in *Science* (1949, **110**, 203) he used data derived from intelligence tests given in Charkov in 1929. However, in the book he abandoned these data as unsatisfactory and used in their place a table showing correlation coefficients between mental test scores of infants, and the earnings of fathers in Kazan in 1938 (*Principles of Human Genetics*, p. 515), not realizing that infant mental tests used at that time were in the experimental stage and had doubtful value. This is the sum total of his proof for the likelihood that the present differential fertility of different socioeconomic groups "has a dysgenic effect in regard to intelligence."

Curt Stern's basic error, and one that is characteristic of many geneticists, is to give credence to intelligence tests modeled after the Binet tests as instruments for establishing genetic differences. It is not enough for him to make qualifying comments such as

> Psychological tests which measure mental differences are imperfect indicators of the genetic nature of such differences, since psychologists have not yet fully succeeded in devising tests which are equally intelligible to individuals who have grown up in different social surroundings

(p. 515), and then to proceed to declare

> Yet even with these imperfections of the tests in mind, the results . . . strongly suggest hereditary influence.

This might have been excusable in 1940, when Osborn wrote *Preface to Eugenics*, although such a contention is debatable. But recent detailed investigation on what is measured by intelligence tests in use by W. Allison Davis, Robert J. Havighurst, and their co-workers (*Sci. Mon.*, 1948, **66**, 301; Davis, W. Allison. *Social Class Influence upon Learning*. Cambridge, Mass.: Harvard Univ. Press, 1948) have proved unequivocally that the differential scores of persons classified according to the occupations of their parents are explicable entirely in terms of the nature of the tests themselves. These studies render spurious any surmises about genes of intelligence determining the scores of conventional intelligence tests, and they negate the geneticists' further use of I.Q. scores in the way that Curt Stern has used them. The Davis and Havigurst studies go beyond the earlier researches, which had cast doubt upon the value of the tests in measuring innate abilities by showing how I.Q.'s vary among races when socioeconomic environments vary—for example, when Negroes have better economic, educational, and cultural opportunities in the North than they have in the South and by showing the differences in I.Q.'s between rural and urban populations, between upper and lower income groups of closely related peoples, and between identical twins raised apart. Davis and Havighurst have regarded it as the crux of their problem to discover just why the intelligence tests have proved to be more difficult for the lowest socioeconomic group.

Discrepancies in the scores were found to be caused by the fact that the tests use chiefly words, situations, pictures, and experiences which are much more familiar to individuals who have grown up in middle and upper socioeconomic groups. The conventional tests measure,

therefore, not the real intelligence of the child or adult, but the cultural and economic opportunities they have had. Davis and Havighurst have demonstrated experimentally that by constructing tests in which only such words, grammatical constructions, and situations are used as are about equally common in the environments of all socioeconomic groups the difference in scores between individuals in all groups remain. (Davis, W. Allison. "Education for the Conservation of the Human Resources of the United States." Address, Amer. Assoc. School Admin., Feb. 21, 1949; and Haggard, Ernest A. "Influence of Culture Background on Test Performance." Paper, conference on testing problems, Educational Testing Service, Oct. 29, 1949.)

It should be noted that although the assumption of psychological differences along class lines reiterated by Curt Stern is arrived at inferentially, the fact that environmental variables are significant in psychological growth has repeatedly been documented by cultural historians, psychologists and educators (see, e.g., Kluckhohn, C. and Murray, Henry A. *Personality in Nature, Society and Culture.* New York: Alfred A. Knopf, 1948.). However, because of their biases in assuming hereditary causes for divergent scores in intelligence tests along socioeconomic lines, schools have failed to recognize and to develop fully the potential mental ability of the children in this country who are from working class families. The failure in America to take advantage of the abilities of the working class population was strongly corroborated by the experience of army psychologists during World War II working on the problem of the discovery, development, and conservation of aptitudes. It was demonstrated that the limitations of the large group of functional illiterates and slow learners could be greatly ameliorated through an educational program (Bingham, Walter C. *Science,* 1947, **106,** 156.). Even more important was the evidence that among more than 3,000,000 men in the higher levels of learning ability, interviewers for army personnel classification found that almost 1,000,000 had not even completed a high school course, much less gone on to a technological institute, a college, or a professional school, largely because they lacked the means (Bingham, Walter V. *Science,* 1946, **104,** 147). An approach to the problem which infers differential psychological potentialities according to socioeconomic groupings puts a heavy restraining hand upon attempts to enlarge educational opportunities of lower income groups. It encourages diversified education along class lines, with inferior facilities for the poor because they are regarded as less satisfactory material. As a result, class stratification is buttressed.

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In the chapter on "Selection and Eugenics" the weighing of the evidence has led me to reach the tentative conclusion that there are genetic differences in the mean intellectual endowment of the different socioeconomic levels. No certainty regarding this conclusion has been claimed in any of the various formulations which can be found in the relevant pages of the book.

Bernhard Stern's critique rests essentially on his statement that

> recent detailed investigation . . . by Davis, Havighurst and their co-workers have proved *unequivocally* that the differential scores of persons when classified according to the occupations of their parents are explicable *entirely* in terms of the nature of the tests themselves

(italics mine). The data presented by Davis and Havighurst do not warrant as sweeping a statement as this. These authors have shown, more vigorously than before, that cultural, i.e., environmental factors play a significant role in the test-scores of socioeconomic groups, but there is nothing in their studies that enables one to state unequivocally that no genetic component is present in addition to the cultural. Davis and Havighurst (*Scientific Monthly,* 1948, **67,** 313) themselves, in replying to criticisms by A. S. Otis (*Scientific Monthly,* 1948, **67,** 312), write

> . . . he says that we assume that all socioeconomic groups are equal in innate intelligence. This is stating our position a little more strongly than we would do; we would rather say that in view of what is now known about genetics and about intelligence testing, the safest *assumption* is that the several socioeconomic groups in the United States are equal in innate intelligence. *We cannot prove* this on the basis of evidence at present available. . . .

(italics mine).

The last sentence quoted in the preceding paragraph continues

> . . . but neither can the assertion that socioeconomic groups differ in innate intelligence be proved with evidence now at hand.

I agree with this statement if emphasis is placed on the word *prove.* It is, however, legitimate to look at the totality of evidence already at hand and to attempt an evaluation which, of course, is subject to change when new evidence has accumulated. After going over a considerable body of evidence of which only a limited amount, selected as representative, has been cited in my book, and not having started with a preconceived opinion, I found it indeed "hard to avoid the conclusion . . . that there *are* mean differences in the genetic endowment of the different socioeconomic groups."

Bernhard Stern's specific criticisms are (1) that I have ignored Osborn's recognition of "the many weaknesses of the studies themselves," (2) that I have paid no attention to a "warning" by Osborn according to which testing of preschool children "is not so valid as for the school years," (3) that I did not realize that infant mental tests in 1938 were of doubtful value, and (4) that after initial use I have "abandoned" certain data from Russia "as unsatisfactory." Some of these criticisms might be valid if I had expressed an unequivocal opinion rather than one couched in terms of probability. But the way in which the opinion was expressed is witness of my awareness of debatable aspects of the evidence. Moreover, *ad* (1), Osborn's comment regarding "the many weaknesses of the studies themselves" was not made when he drew his conclusion as to the

probable *existence* of innate differences between socioeconomic strata but when he discussed the problem of estimating relative to environmental differences the *size* of such a difference. Again, *ad* (2), his footnote regarding the testing of preschool children has no implication of a "warning" and refers not to the *fact* of differences but to the numerically somewhat different scale of scores from preschool as compared to older children. In principle, differences in the same direction were recorded for both young and older children of different socioeconomic groups. *Ad* (3), that infant mental tests in 1938 were of doubtful value, it may be replied once more that the unsatisfactory nature of these tests concerns rather their exact quantitative aspects than the qualitative establishment of test differences. Finally, *ad* (4), Bernhard Stern's reference to my having abandoned certain data as unsatisfactory is inadmissible. The data may be found on page 516 of my book unchanged from their presentation in the *Science* article. They were neither abandoned nor called unsatisfactory.

My interpretation of the evidence may not be shared by some or many, but, contrary to a claim made by Davis and Havighurst, it is at least fully compatible with our knowledge of human genetics. These authors say: "From what is known about genetics, the children of a man who was well favored with innate intelligence would have very little chance of being better favored than the children of a man who was less well endowed genetically in these respects." This statement is based on the arguments that "both men carry many latent characteristics as well as manifest ones" and that their wives contribute half the genes to the offspring. But these facts bear only on the *degree* of heritability, not on the genetically expected existence of heritability. Given the premises made by Davis and Havighurst of the existence of men favored with innate intelligence and of others less well endowed, genetic knowledge leaves no doubt that, on the average, the children of the former are again innately more favored than the children of the latter.

I should like to conclude these comments with a general remark. It is one thing to express an opinion on the weight of scientific evidence and another to draw practical conclusions from one's judgment. In my published discussions I have pointed out repeatedly the preliminary nature of the conclusions reached, their very limited eugenic significance, the lack of urgency of the eugenic problem, and the great importance of the environmental component. The censure of my judgment as manifesting "conventional biases" seems based primarily on the potential sociological misuse of such judgment. Censure of this kind is contrary to the essence of free inquiry and implies a desire to impose doctrinal limitations to the study of observable phenomena. We must be free, however, to reach conclusions, preliminary or supposedly final, regardless of the misuse to which they may be subjected. In the condemnation and combat of their misuse we all can join hands.

CURT STERN

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American Men of Science

There has been much interest in the letters which the undersigned sent to those included in *American Men of Science*. Because a number of persons completely misunderstood the purpose of the letters, as editor, I shall try to clear the matter for all concerned. The directory has a great value and fills a great need to American men of science.

Your editor set the advance paid price at $9.50 when it should have been $12.00. On the $11.00 advance unpaid orders, the same situation exists, as the $1.50 difference is almost entirely consumed by additional accounting costs. In three years costs increased that much. It cost $200,000.00 to put out the eighth edition of the directory. There were 50,000 names listed and editorial costs came to $100,000.00, which is $2.00 each.

There were two letters sent out: one was a letter to those who bought a copy and they were asked to pay $2.00 additional to cover the increased cost of their copy; the second was a letter to those who did not order a copy. This group was asked to help defray the costs of editorial work in connection with their biography. Almost everyone uses either someone else's copy, or a library copy, so it was felt that most of this group would be glad to help to the extent of the $2.00 editorial costs.

However, a few persons have inquired about the intent of the second letter, believing that if no $2.00 were sent, biographies might be omitted. This is quite erroneous. Nothing was further from that thought when the letter was mailed. If such a letter were sent to those being considered for inclusion in the directory there might be cause for concern. But everyone who received the letter is already included in the directory.

No record is being kept for editorial use of those who sent $2.00. If anyone sent $2.00 for the reason of editorial influence they should ask for a refund.

Obviously, had it been a money-making scheme more than $2.00 would have been asked. It was hoped that a sufficient number of those who received the letters would contribute enough to make the directory secure, but it will fall short of that figure, unless more are received.

The fact that we returned over 200 $9.50 advance paid orders of those who in our judgment were not eligible for inclusion proves that inclusion cannot be bought.

We are grateful to the many thousands who understood our letters and heped us with our financial problem. The book will be priced higher for the ninth edition; we hope this will take care of all expenses.

We want to assure all those in science in America that the high plane of editorial policy will never change so long as the undersigned is editor. He has been editor for over 20 years.

JAQUES CATTELL

Editor, American Men of Science

Committee for Aid to Foreign Physiologists

A committee was set up in September, 1948, by the American Physiological Society to aid foreign physiolo-

gists. The committee is taking this opportunity of reporting its work, so that it may acknowledge the help it has received from various organizations and publicly express its thanks. It hopes also that this report will encourage others to extend the program.

Subscriptions from society members have provided a total of some six hundred dollars, an amount which obviously cannot significantly reduce foreign shortages of literature or equipment. Real success, however, has been achieved in promoting good will. The present program in literature does not compete with the much more ambitious program now being organized by CARE, which should be supported to the fullest extent possible, but the society's program can still fill gaps and play a useful supplementary role.

In order not to dissipate its efforts over too large an area, the committee decided to limit its main activities to a few schools in countries in which the United States has particular interests. The selected medical schools are those in Salonika, Naples, Frankfurt, Würzburg, and Tohoku. Some additional help has gone to other schools, including help to China.

Reprints. Reprints of recent literature are very valuable. Considerable numbers (with multiple copies) have been sent to these schools, and are being lent in turn to other schools. The Japanese Physiological Society has even set up a "Loan Library with American Reprints" in Tokyo and arranged to lend such reprints by mail throughout the country. This effort should receive our full support. The International Exchange Service of the Smithsonian Institution is undertaking to forward such collections of reprints or other literature to foreign countries. Will any physiologists with supplies of recent reprints kindly send them to these schools.

Textbooks are also much in demand and copies of standard texts recently replaced by new editions would be welcomed abroad in all of the schools. They may be forwarded to the schools directly or through the Smithsonian Institution. The society is greatly indebted to publishing firms, which have sent abroad hundreds of obsolescent volumes. Our thanks are due to Saunders, Lea and Febiger, Appleton-Century-Crofts, Inc., Chemical Rubber Publishing Company, and particularly to the Year Book Publishers, which donated 105 copies of its current year books, and to Williams and Wilkins, which sent abroad a total of 215 volumes.

Journals published in the United States are badly needed; a few have been sent abroad by special subscriptions and others are being sent after the subscriber has used the current numbers. Thus, the *American Journal of Physiology* and the *Journal of Clinical Investigation* are being sent to Würzburg and used copies of *Biological Abstracts, Journal of Aviation Medicine, American Heart Journal, British Physiological Abstracts,* and *Proceedings of the Society for Experimental Biology and Medicine* to Salonika, Naples, or Nagoya. Up to the present time only single sets of these have been available, so that there is ample opportunity for physiologists to extend this list or to add new sets so that other schools can be supplied. The publication trustees of the society have also sent abroad some of the society's journals for the period when foreign subscriptions were unavailable and have donated excess stocks of other back issues.

Equipment. Very little equipment can be bought with the small funds available, which in the main are being used to pay transport costs. Two used metabolism machines have been sent to China from West Coast laboratories, and a considerable amount of obsolete teaching equipment has been sent to Naples from the University of Pennsylvania. Through a generous gift by the Aloe Company, new equipment valued at $1000 or more (made available during recataloguing) has been sent to Frankfurt, and requests for amino acids made by Frankfurt and Würzburg have been partially met by General Biochemicals, Inc. The A. H. Thomas Company has donated the assistance of skilled packers, and technicians at the University of Pennsylvania, including James Graham, the university glass-blower, have contributed time, labor, and glass equipment. For these aids we extend our thanks.

Reciprocity. The Italians and Japanese have shown their gratitude by presenting the society with current numbers of the *Bolletina della Societa Italiana di Biologia Sperimentale* and of the *Tohoku Journal of Experimental Medicine.* Any school with limited library facilities, which would like to receive these journals, may apply to the executive secretary of the society.

Needs. The University of Salonika needs a photoelectric colorimeter. Any such instrument, used or rebuilt (if in usable condition), will be welcome to the committee, which will pay for transport, or assume other costs within their means.

Reprints, books, or other material should be forwarded to the departments of physiology in the universities listed or, if for China, sent to the American Bureau for Medical Aid to China, 1790 Broadway, New York 19, New York. Large packages of literature for forwarding abroad to countries other than China, can be sent through the Smithsonian Institution, International Exchange Service, Washington, D. C. Carriage should be paid to Washington and the institution should be notified of the packages consigned. Reprints of biological papers for the Japanese Reprint Loan Library should be sent directly to Professor Kunizo Hukuda, Department of Physiology, Medical School, University of Tokyo, Hongo, Tokyo, Japan.

MILTON L. LEE

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Education and Training for Oceanographers[1]

The shortage of scientists is general. Two circumstances combine, however, to exaggerate the present need for men trained in oceanography. Revolutionary developments in the military techniques of the late war created an unprecedented demand for knowledge of the sea and for trained oceanographers. Knowledge of the sea can contribute to the solution of peacetime as well as military problems. Thus, the state of the postwar world makes it

[1] Contribution No. 519 from the Woods Hole Oceanographic Institution and contribution from the Scripps Institution of Oceanography, New Series, No. 463.

only too clear that the food resources of the sea must be exploited to the utmost. Oceanographers are needed to lay foundations for technological advances in military techniques, in transportation and communication across the sea, and in the expansion of sea fisheries. Yet no increase of effort in the investigation of the sea is possible, since all trained oceanographers are now employed.

Three factors must be considered in connection with oceanographic training: (a) What positions may students look forward to after receiving their oceanographic education? (b) What distinguishes oceanography as a separate scientific discipline requiring a special combination of skills and interests? (c) How can such skills be obtained within the usual academic pattern, or what special modifications and additions does this pattern require?

Opportunities for employment in oceanography exist primarily in the federal government and in university or associated research laboratories. Within the federal government the Hydrographic Office, the Coast Guard, the Geological Survey, the Coast and Geodetic Survey, the Office of Naval Research (including the Naval Research Laboratory), the Bureau of Ships (including the Navy Electronics Laboratory and the U. S. Navy Underwater Sound Laboratory), the Naval Ordnance Laboratory, the U. S. Engineers, and the Beach Erosion Board, are the principal agencies interested in physical oceanography. The Fish and Wildlife Service of the Department of the Interior, the conservation agencies of many maritime states, and various international fisheries commissions are interested in oceanography from the biological standpoint. Private interests in oceanography include the oil companies now engaged in an extensive search for new oil reserves under continental shelves.

Two well-established oceanographic laboratories are maintained by universities: the Scripps Institution of Oceanography of the University of California (including the Marine Physical Laboratory) and the Oceanographic Laboratories of the University of Washington. A third laboratory, the Chesapeake Bay Institute, has been established recently at The Johns Hopkins University. The Woods Hole Oceanographic Institution, an independent foundation, provides facilities for investigators from other institutions and maintains its own professional staff as well. The other institutions represented have included Harvard, Brown, Yale, Columbia, Rutgers, Princeton, New York, and Queens Universities, the Massachusetts Institute of Technology, the Universities of Chicago and of Maine, and Amherst, Wellesley, Barnard, and Rhode Island State Colleges.

Marine research involving oceanography is conducted by the Bingham Oceanographic Foundation at Yale, the Department of Engineering of the University of California at Berkeley, the Department of Geology at Columbia, the University of Southern California, Harvard University, New York University, the University of Miami Marine Laboratory, and other biological laboratories. Research closely akin to oceanography is being done on the Great Lakes and on smaller lakes throughout the country, most notably at the Universities of Wisconsin, Michigan, and Chicago and at Ohio State and Northwestern Universities.

Although these lists suggest a rather extensive interest in oceanography on the part of government and educational institutions, the number of persons in the profession is small. A recent survey of manpower available for research in oceanography lists 448 persons, and only 223 of them are reported to be doing independent research or to have done it recently. The number of graduate students now in training is about 80. There is an immediate need for 30–40 oceanographers throughout the governmental and other oceanographic institutions of the U. S., and when the present large demand levels off it is believed that ten or more newly trained oceanographers will be required each year to take care of normal replacements and expected growth. As in many other fields of science and engineering, needs exist both for highly trained men capable of carrying on oceanographic research independently or under very little supervision, and for men of less advanced training, for positions involving oceanographic engineering, surveying, or reducing and compiling of data. In addition, special provision should be made for the training of officers of the Department of Defense, who should profit greatly from intimate contact with the techniques of a field science such as oceanography, even though their professional responsibilities are primarily administrative.

The present professional oceanographers in the U. S. have received their training for the most part in physics, chemistry, biology, or geology. Until recently, organized training in oceanography as such has been available only at the University of Washington and at the Scripps Institution at La Jolla. Courses in oceanography are also given as part of various curricula at Harvard, Columbia, St. Louis, Clark, Brown, Cornell, and New York Universities, at the Agricultural and Mechanical College of Texas, and at the Universities of Chicago, California (at Los Angeles), and Southern California. Amherst College has pioneered in offering instruction in oceanography as a part of the liberal arts curriculum where it shows the value of the basic sciences for interpreting the phenomena of the natural world.

Oceanography acquires its unity because it deals with everything taking place in a limited geographical subdivision of the earth—its watery envelope. Problems in oceanography fall rather definitely into two groups, those of geophysics and those of ecology. Their solutions require the various techniques of physics, chemistry, geology, and biology. It is pertinent to ask whether oceanography has its own peculiar disciplines or whether it is merely a collection of those parts of these other sciences which happen to deal with the phenomena of the seas.

In order to answer this question it is necessary to consider briefly the intellectual content and methods of oceanography. Oceanography may be defined as the study of the ocean in all its aspects, including the interrelationships between marine organisms and their environment and between the ocean and its boundaries—the atmosphere, the sea bottom, and the shores. In contrast to the exact sciences, it deals with the investigation of condi-

tions and processes as they exist on a large scale in nature rather than with the conduct of controlled experiments in the laboratory. The conditions in the sea cannot be controlled; moreover, they are characterized by a high degree of complexity, great geographical diversity, and variability with time. The nature of oceanography is determined by these characteristics as well as by the large dimensions involved and by the fact that the fluid nature of the medium results in widespread interrelationships.

The oceanographer is concerned primarily with the elucidation of the individual processes in the sea which together produce the observed conditions. In general, two or more processes oppose each other and are balanced in such a way that a state of approximate equilibrium is maintained. The principle of dynamic equilibrium may be thought of as a unifying principle of oceanography, in much the same way that the principle that the present is the key to the past underlies and unifies geology. The problems of oceanography require analysis of observed conditions that represent the integration of several processes so as to differentiate and describe the individual processes that are at work. Two methods are commonly employed for this purpose: (a) All possible parameters in a given situation are measured and processes are deduced which explain the observed relationships between these parameters in terms of physical, chemical, and biological principles; (b) Comparative studies are made of variations in certain parameters in many situations. These studies can be facilitated in some instances by model experiments in tanks, in which individual processes can be controlled. Statistical correlations are then carried out to obtain empirical relationships, or preferably a simplified theoretical model is constructed and shown to correspond in essential features to the complex reality.

Although no individual method or principle of oceanography is unique, it is believed that the combination of principles and methods just described forms a distinct discipline which requires special training.

When the diverse quality of the disciplines on which oceanography depends is considered, together with the present limited opportunities for professional employment, it appears doubtful whether there is need for new organizations for specialized training in oceanography. What is required, rather, is the establishment of professional standards for oceanographic training. These can largely be met within the existing academic pattern of universities that recognize the special training requirements. Since oceanography comprises such a wide variety of problems no individual can become fully competent in all its departments. Depending on his interests and aptitudes, a student must specialize in the physical, biological, geological, or chemical aspects of oceanography. It is essential, however, that each worker understand the concepts and the language of the entire subject. In a field with limited outlets for employment it is important that the basic training be broad enough to equip students for jobs in related branches of geophysics, geology, or biology. Such breadth of training will give a wider base for the later development of a professional career and greater opportunities for intellectually satisfying research. There is need in the field sciences for research workers whose education has followed the pattern proposed herein.

With this objective in mind, we have prepared a list of subjects recommended for the basic training of a student who anticipates a professional career in oceanography. Clearly, the quality of the student's general education, and the extent to which he has been infused with scientific curiosity and the research spirit, are of primary importance in the training of any scientist. We have limited ourselves here, however, to technical aspects of basic training of special value for oceanographers.

RECOMMENDED SUBJECTS FOR OCEANOGRAPHIC TRAINING

Mathematics
- Algebra and trigonometry
- Analytical geometry
- Differential and integral calculus
- Differential equations
- Statistics
- Advanced mathematics, including vector analysis and Fourier integrals

Physics
- Basic physics, including mechanics, heat, sound and light, and electricity and magnetism
- Wave theory and acoustics
- Electronics laboratory
- Hydrodynamics or fluid mechanics
- Advanced mechanics or theoretical physics

Chemistry
- General inorganic chemistry
- Analytical chemistry
- Organic chemistry
- Physical chemistry
- Colloid chemistry
- Microchemical analytical techniques

Biology
- Elementary biology
- Invertebrate zoology
- Physiology
- Biochemistry
- Microbiology
- Ecology or limnology
- Advanced biology
- Biophysics, including applications of nuclear physics
- Summer work in marine biology

Geology
- Physical geology
- Historical geology
- Paleontology
- Introductory mineralogy and petrology
- Crystallographic and optical mineralogy
- Sedimentology or marine geology

Geophysics
- Principles of oceanography—physical, biological, chemical, and geological
- Exploration geophysics—magnetic, electrical, gravity, and seismic
- Summer field course in oceanography
- Physical and dynamic meteorology
- Synoptic meteorology
- Climatology
- Advanced physical oceanography
- Theoretical geophysics

These are the scientific subjects that are of direct value in oceanographic training, arranged more or less in their sequence of advancement. In Table 1, a selection is made among these subjects to indicate the relative distribution of effort considered desirable for basic training in the several fields of specialization. The programs of study outlined in Table 1 would require ordinarily about 13

course years, or about 70 to 80 semester hours. Allowing for the usual university requirements for courses in the humanities, languages, English composition, and the like, completion of one of the programs would probably require five years, particularly if the student did not start on the program at the beginning of his college career. Normally, these suggested programs would lead to the master's degree. Additional graduate courses, special seminars in oceanography, and appropriate research would be required for those who work toward the Ph.D. degree.

The listed subjects are fundamental, so that a student could proceed after the first two or three years of study into almost any other field of science without retracing his steps. At their completion the specialist in physical or geological oceanography would be well prepared for advanced work in any aspect of geophysics should he be unable or unwilling to continue in oceanography. The specialist in biological or chemical oceanography would have a better training than is usual among college graduates, for continued studies in ecology, limnology, physiology, or biochemistry. Conversely, students thoroughly trained in geophysics may find excellent opportunities in geological oceanography, and students well trained in biochemistry may make important contributions in biological oceanography.

TABLE 1

DISTRIBUTION OF SUBJECTS IN BASIC TRAINING FOR SPECIALTIES IN OCEANOGRAPHY: COURSE YEARS

	Physical oceanography	Geological oceanography	Biological oceanography	Chemical oceanography
Mathematics	3	2½	2½	2½
Physics	3½	2	2	2
Chemistry	3	3	3	4*
Biology	1	1	3	2
Geology	1	3	1	1
Oceanography	1	1	1	1
Meteorology	½	1	1	1
Summer field work at oceanographic laboratory	x	x	x	x
Summer course in marine biology			x	

* To include biochemistry.

The programs proposed would be adequate for students contemplating an "engineering" career in oceanography and would bring the student who plans to take an advanced degree to the point where his training should become individualized. For each of the four specialties of oceanography, an advanced student should master many more of the subjects listed in Table 1 that are related to his specialty. In physical oceanography, for example, he should try to cover all courses listed in mathematics, physics, and geophysics. In the end he would be fitted for research or teaching in nearly any aspect of geophysics.

Although these basic training programs involve a minimum of specialization, they all include a year's course in the methods and principles of oceanography and a summer of work and study at one of the major oceanographic research institutions. This introduction to oceanography should be experienced as early in college as possible, in order to arouse the interest and enthusiasm of enough students to screen out those without special aptitude for a field science, and to give concrete meaning and purpose to the other more general subjects included in the curriculum. Prerequisites for a general course in the principles of oceanography should include mathematics through differential and integral calculus, a basic course in physics, and an elementary knowledge of chemistry, biology (including taxonomy), and geology. It would therefore not be possible to take this course before the junior year. It should preferably be followed by the summer's field work in oceanography, between the junior and senior years.

A course in the principles of oceanography would be useful to biologists, geologists, and geophysicists, as well as to oceanographers. It would also have general educational value in demonstrating the application of scientific principles and methods to the phenomena of the real world—for example, in exploiting the food and mineral resources of the oceans to help solve problems created by overpopulation.

The general science courses required for basic training in the specialties of oceanography are offered in many universities—what is lacking is basic training in oceanography itself. Any university can institute a program in oceanography if it is prepared to add these introductory courses and provide for advanced study in one of the specialties. Graduate training should, of course, include some experience in research at sea, for which adequate facilities already exist at the established oceanographic institutions.

VERN O. KNUDSEN, ALFRED C. REDFIELD, ROGER REVELLE, and ROBERT R. SHROCK

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Book Reviews

Introduction to Radiochemistry. Gerhart Friedlander and Joseph W. Kennedy. New York: John Wiley; London: Chapman & Hall, 1949. 412 pp. $5.00.

Since its inception in the discovery by the Curies in 1898 that differences in chemical properties can be exploited to separate from pitchblende the two different radioactive elements polonium and radium, the field of radiochemistry has experienced an ever growing importance marked by two great accelerating discoveries—artificial radioactivity, in 1934, and nuclear fission, in 1939. It is now a popular and fertile province of research encompassing large territories of almost all branches of chemistry and of molecular, atomic, and nuclear physics, and even enjoys the ultimate mark of respectability: courses in radiochemistry are being offered by many of our universities.

The student of radiochemistry has long been without an adequate textbook, for the established references—the older works of Soddy; the classic treatises by Rutherford, by Meyer and von Schweidler, by Curie, and by Kohlrausch; the Cornell lectures of Hahn; and the admirable survey by Hevesy and Paneth—although still invaluable compendia of information on natural radioactivity, are all most severely dated. Friedlander and Kennedy have now filled this void with a fine and comprehensive book. Intended primarily for the student of chemistry, their volume should also prove extremely useful to students of physics, and to biologists, geologists, engineers, and others. It provides a modern, mainly descriptive, and simple though remarkably extensive account of radiochemistry and of much of nuclear physics as well. No previous knowledge of nuclear physics is demanded of the reader. Indeed, nuclear physics itself necessarily merits the greatest attention, and only some 60 out of 412 pages deal with essentially chemical matters. The selection of chemistry material is, incidentally just what should be acquired by any *physicist*.

The book is well written throughout and pleasantly free of errors. A great many references, fairly well organized, are included, and numerous skillfully contrived exercises, many with answers provided, enhance its value both for use in the classroom and for purposes of self-instruction. The figures are good, but no reproductions of cloud chamber photographs or photographic emulsion tracks are included—a regrettable omission in the reviewer's opinion, for such pictures, in addition to their scientific importance, have unique pedagogical value. Four appendices include useful reference data.

The appearance of this volume emphasizes the need for a modern laboratory manual, since a laboratory course in conjunction with lectures following this text should do much to complement and vivify the subject matter. It may also be remarked that the book is in no sense an advanced treatise, and the authors have wisely refrained from attempting to make it one. An advanced monograph on contemporary developments and problems in radiochemistry is sorely needed.

As an introductory text this excellent work by Friedlander and Kennedy can be highly recommended.

ROBERT L. PLATZMAN

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The Transuranium Elements: Research Papers, 2 vols. Glenn T. Seaborg, Joseph J. Katz, and Winston M. Manning, Eds. New York: McGraw-Hill, 1949. 1733 pp. $15.00 a set.

The identification and first tracer chemical studies of a true transuranic element were announced in May, 1940; microgram amounts of pure solid compounds of a transuranium element were first prepared in August, 1942. The approximate deadline for much of the work included in this volume of the Plutonium Project Record is January 1, 1946, although some is more recent. The body of chemical and nuclear-chemical knowledge of neptunium, plutonium, americium, and curium contained in the 1,733 text pages of this book is impressive when it is viewed against this timetable.

The volume is important because, with a very few exceptions, it contains the sole scientific report of the chemistry of the transuranium elements written on the level of normal research journal publications that is available to the general body of scientists. It is fair to say that the detailed understanding of neptunium and plutonium achieved since May, 1940, as it is revealed here, approaches our present understanding of most common elements, and far exceeds the reliable information we have about many naturally occurring elements known to science for much longer periods of time.

As indicated, the book is a compilation of research papers which in the normal course of events would have seen journal publication. As would be true of any volume comprising all papers dealing with a single element or group of elements, *The Transuranium Elements* exhibits great unevenness. Notes such as are published in "Letters to the Editor," significant principally for historical reasons, are found side by side with papers as long as 45 printed pages, recording in detail work which was obviously pursued over a considerable period of time. Work that was involuntarily interrupted also contributes to the unevenness, as do the idiosyncrasies and varying degrees of experience of the many authors represented. Many of the papers meet the most exacting journal standards for concise clarity, but because of editorial choice and the absence of journal space limitations, the papers as a whole probably take more room than they otherwise might. In some cases this results in the reader's being given more information on important details than he might get in standard journal publications. One clear advantage this group of papers has over a compilation from normal journals is that errors

of fact and interpretation in early work have obviously been caught and eliminated at various stages prior to publication of the finished volume, so that it presents a considerable unanimity of opinon. This is not to say that other errors may not be revealed by later researches.

Approximately half of the papers may be classed as physical or nuclear-chemical in content, and half as chemical. Some three-quarters of the papers deal with plutonium, about one-sixth with neptunium, and only a few with americium and curium. Partly because of the comparative nature of some studies, papers dealing with the rare earths, radium, actinium, thorium, protactinium, and uranium are also found. Aside from the large body of data on the synthetic elements, the greatest contributions of the volume to other fields of science are techniques and instruments developed for nuclear-chemical studies, particularly with alpha emitters, and the demonstration of the possibilities for ingenious applications of microtechniques to problems in inorganic chemistry. The book also has a pedagogic value for research students, in demonstrating the applications of textbook material to actual laboratory problems, and the methods used to obtain scientific data in new situations.

LEONARD I. KATZIN

Argonne National Laboratory

Traité de Zoologie: Anatomie, Systématique, Biologie: Oiseaux, Vol. XV. Pierre-P. Grassé, ed. Paris VI^e, France: Masson et Cie, 1950. 1164 pp. 6000 fr.

With the appearance of this thick volume all students of avian biology are aided in their work by a comprehensive treatise that is literally packed with useful information, well presented and amply illustrated, and accompanied by well-selected lists of references to the literature. Unlike the similarly comprehensive volume written by Stresemann some years ago, the present work is the product of a group of authors. The advantage of a group of specialists' pooling their information is often offset by a resulting lack of uniformity in approach and presentation, but the editor of this volume has overcome the lack to a remarkable degree, and the volume is free from the literary jerks and mental changes of focus usually found in such composite treatises.

N. Mayaud contributed six chapters, on skin and plumage, biology of reproduction, food, longevity, voice and nonvocal sounds, and behavior and social life; A. Portmann eight chapters, on skeleton, nervous system, sense organs, circulatory system, respiratory system, digestive tract, body temperature and warm-bloodedness, and postembryonic development; E. OEhmichen three chapters, on musculature, flight, and terrestrial locomotion, swimming, and diving; P.-P. Grassé two chapters, on the uropygial gland and the organization of social life; A. Rochon-Duvigneaud a single chapter, on eyes and vision; J. Benoit three chapters, on endocrine glands, urogenital system, reproduction-sexual characters and hormones in relation to the seasonal sexual cycle; R. Matthey one chapter, on chromosomes of birds; J. Pasteels one chapter, on embryonic development; F. Bourlière two chapters, on ecological factors and adjustments, and physiology of migration; J. Piveteau one chapter, on the origin and evolution of birds; J. Berlioz three chapters, on the systematic description of the subclasses, orders, and families of birds, geographic distribution, and general aspects and origin of migration; and E. Letard the final chapter, on domestic birds' origin.

The contents of the book are made readily accessible by a good index and a detailed table of contents. The illustrations and the text are well printed but the type of paper used is not uniform throughout the book. The volume should be of great use and value to workers in many and diverse fields that utilize avian materials in their studies, and deserves a wide distribution among scientific libraries.

HERBERT FRIEDMANN

U. S. National Museum

Survey of Biological Progress, Vol. 1. George S. Avery, Jr., ed. New York: Academic Press, 1949. 396 pp. $6.80.

This stimulating volume is the first *Survey of Biological Progress*, and is the result of an undertaking which its editors hope will be repeated annually. In the words of its editor-in-chief, it is designed to provide "a medium for integrated presentation of facts and thoughts from all fields of biology," "to offset in a certain measure the isolating effect of rapidly increasing specialization" and "to serve the biologist who wishes to be well-informed in fields marginal to or beyond his own special sphere of interests—fields he would have neither the time nor opportunity to follow systematically in the original literature." The editorial staff and the advisory board, along with the twelve authors and the institutions they represent, are indicative of the high standards of the articles included in the *Survey* and the dependability of its contents.

The volume includes eleven chapters, the first of which is a discussion by Harriet B. Creighton on "Teaching Biology Today"—a brilliant and challenging presentation of the general goals in teaching an introductory course in biological science. The remaining chapters are devoted to recent developments in a large area of biology, in some instances of fundamental sciences and in others of applied sciences.

Many chapters emphasize the influence of findings in one field on the interpretations of known facts in allied fields. The outstanding importance of cancer research and the aspects of cellular physiology to which it is related is indicated by the fact that 42 percent of that part of the volume relating to current research is devoted to a consideration of viruses, enzymes, genes, and antigens and their interrelations as well as their relationships to cancer problems. There are 594 references in the four chapters covering this large segment of the book.

In his stimulating chapter on "Genes and Gene Action," Bentley Glass shows how current researches on the nature of gene action are uniting the "phenomena of classical genetics, cytoplasmic inheritance, cellular differentiation, and enzymatic adaptation." After summarizing Sonneborn's view that "cancer may result

either from the introduction of a virus into the cell or from the mutation of a plasmagene, and that carcinogenic agents either make the cells more sensitive to viruses or induce mutations in plasmagenes," he concludes that "this theory may prove to be as fruitful in increasing our knowledge of the gene and the mechanism of gene action, as in opening up a new approach to the conquest of the second, in present importance, among the causes of human death." He further elucidates Spiegelman and Kamen's theory relating gene activity and plasmagenes to the synthesis of enzymes and proteins. His final conclusion is that "Genes, antigens, enzymes and plasmagenes are being related to one another and may soon disclose how genes produce their effects—and perhaps how cancers arise."

Donald Paul Costello, in "Growth and Development," emphasizes the strong union which is now being welded between embryology and biochemistry, owing largely to attempts to trace morphogenetic processes back to their biochemical precursors. According to Dr. Costello, the major problem in embryology today is "the origin of diversity in development," and one of the four approaches to this problem he proposes is "the origin and characteristics of the differential metabolism of the parts with elucidation of the enzyme systems involved."

In his comprehensive and excellently illustrated chapter on "Virus Tumors," L. M. Black clearly presents recent developments in virus studies in general and virus tumors in particular, from both the plant and the animal standpoint. He urges in conclusion that "Because of the demonstration of virus etiology in some cancers it seems important that the virus approach to the problem be vigorously prosecuted. Only by strenuous attempts to verify the hypothesis of virus etiology wherever it is indicated (and perhaps also where it is not indicated) can the virus concept make its full contribution to an understanding of tumors and cancer."

In "Growth Hormones and Tissue Growth in Plants," Philip R. White points out that tissue culture work has demonstrated that the capacity of a tissue to produce growth hormones may become greatly enhanced over that in normal tissues and that "this altered capacity for hormone production appears to be responsible for the development of certain malignant types of tumors in plants. The mechanisms involved in this enhancement are not fully understood. They present several possibilities, each of which has its counterpart in the theories of the mechanisms of cancer production in animals and man."

There are two additional chapters on subjects in somewhat related fields. Karl E. Mason, in "Nutrition and Reproduction," emphasizes the importance of vitamins as well as proteins, fats, carbohydrates, and minerals to reproduction in invertebrates, fishes, amphibia, reptiles, and birds, as well as mammals. In "Hormones and the Differentiation of Sex" Robert K. Burns presents the problems of the morphological development of sex organs as related to specific sex hormones in amphibia, birds, and mammals. The excellent illustrations are helpful in following complex morphological developments.

A new, challenging, and potentially useful technique is presented by Martin D. Kamen in "Tracer Methods in Biological Research," as he examines "the status of tracer research, especially with regard to potentialities." After giving the bases of tracer methodology he presents applications to biochemical and physiological research.

Karl C. Hamner, in his chapter on the "Influence of Environmental Factors on the Vitamin Content of Food Plants," treats the question of vitamins from the standpoint of the plant scientist concerned with increasing the vitamin content of plants so that they may better serve as a source of nutrition for man and other animals. Similarly, W. A. Frazier, in "Newer Methods in the Rapid Development of Disease-resistant Vegetables," presents the problems connected with developing improved sources of food. Plant breeding, as an applied science of fundamental importance to the welfare of man, requires an extraordinary breadth of knowledge and experience on the part of the men who work on these problems. "The plant breeder of today," he writes, "may need to give thought to problems ranging from rearing of blowflies and maintenance of weed nurseries to physiologic races of pathogenes, cytogenetics of incompatibilities, techniques of vitamin determinations, on to the genetic and biometric problems surrounding inheritance of such important quantitative characters as yield and fruit size."

G. E. Hutchinson and E. S. Deevey, Jr., authors of the chapter on "Ecological Studies on Populations," emphasize the importance of cooperation between the naturalist, the taxonomist, the experimentalist, and the mathematician, if a fundamental approach to the science of ecology is to be made. This cooperation is becoming more and more apparent and is a healthy reaction, the authors say, "from the time when the field naturalist was a rank amateur, the taxonomist a mere stamp collector, the experimentalist out of touch with nature, and the theoretical worker incomprehensible and overspeculative." This is the only chapter that even approaches anatomy, taxonomy, and gross morphology—large sectors of the biological sciences which most certainly deserve mention along with the experimental aspects of biology in a *Survey of Biological Progress* if the intended aim as stated in the preface is to be achieved. It is further to be noted that the list of editors does not include outstanding names in any of these fields. There is an ever present danger that funds and publicity may contribute to overdramatization of those areas of science that most easily catch the fancy of the public, and thereby help to produce an unbalance which might eventually reflect itself in editorial policies discriminating against review of the less popular areas of investigation and a resultant disservice to scientific progress generally. Since this is to be an annual publication, the editors will have ample opportunity another year to remedy this omission or to limit their review by some such qualified title as *Survey of Progress in Experimental Biology.*

FANNY-FERN DAVIS

Washington, D. C.

News and Notes

Report on Caribbean Soils Conference

Howard Meyerhoff
Administrative Secretary, AAAS

On April 3 sixty experts in soils science and related fields gathered at the Agricultural Experiment Station of the University of Puerto Rico at Río Piedras to discuss soil types, distribution, and problems in the Caribbean countries. Sponsored by the Caribbean Research Council of the Caribbean Commission, the conference was invitational, but the invitation list was designed to bring the maximum number of experts together for deliberation on common problems; hence it transcended the rigid statutory limits of representation imposed on most meetings sponsored by the Caribbean Commission. In addition to the secretariat and officials of the commission, there were 12 official delegates from the American, British, Dutch, and French Caribbean possessions, 44 observers—chiefly from Puerto Rico and the United States—and 16 official visitors, including representatives from Colombia, Dominican Republic, Haiti, and Venezuela.

At the opening plenary session on April 3, Eric Williams, deputy chairman of the Research Council of the Caribbean Commission, presided. Following an address of welcome by Jaime Benitez, chancellor of the University of Puerto Rico, and a brief address by Bernardo G. Capo, acting director of the University's Agricultural Exeriment Station, the conference was organized for the conduct of official business. Juan A. Bonnet, chief of the Soils Division of the Agricultural Experiment Station, University of Puerto Rico, was unanimously elected chairman of the conference. Roy W. Simonson, of the U. S. Department of Agriculture, was named chairman of the Committee on Soil Surveys, with F. Hardy, of the Imperial College of Tropical Agriculture at Trinidad, rapporteur; Hugh F. Allison, director of the Soil Conservation Surveys in Puerto Rico and the Virgin Islands, was named chairman of the Committee on Soil Conservation, with J. B. D. Robinson, of the Department of Agriculture in Barbados, rapporteur; R. D. Hockensmith, chief of the Soil Conservation Surveys Division of the U. S. Department of Agriculture, was named chairman of the Committee on Land Classification, with A. B. Lewis, of the Food and Agriculture Organization, rapporteur.

Fifty-two papers were prepared long enough in advance of the conference to be mimeographed, and copies were placed in the hands of all those in attendance upon their arrival. Practically every aspect of Caribbean soils was covered in this collection of manuscripts, which included one paper on the geologic background of the Antilles, several on soil types and soil distribution in the Caribbean islands and peripheral countries, a number dealing with the formation and compositional characteristics of tropical and subtropical soils, a small suite of papers discussing soil conservation problems, and a few dealing with land use and land classification in such tropical environments as the Caribbean. The scope of the papers was eloquent testimony of the need for such a conference, which was initially inspired by a meeting in St. Thomas of the Anglo-American Caribbean Commission in August, 1943. Although it took seven years for the conference to materialize, it was obvious that a great deal of thought was contributed in planning the meeting by the Preparatory Committee under the chairmanship of J. A. Bonnet.

With preprints in the hands of every official delegate, observer, and visitor, no time was wasted in paper-reading sessions. Instead, the three committees on soil surveys, soil conservation, and land classification went into separate sessions to consider specific problems in their respective fields. Committee work was supplemented by plenary sessions, directed by a "drafting steering committee" headed by Dr. Bonnet. To assure discussion of general problems and to facilitate the exchange of views and experience, a series of evening seminars was organized, starting Sunday evening, April 2, and running each evening through Friday, April 7.

As a prelude to the sessions at Río Piedras there was a two-day field trip (March 31 and April 1) across the mountainous backbone of Puerto Rico via the old Spanish military highway from San Juan to Ponce, with a side trip to Cidra. From Ponce the route followed the coastal highway via Yauco, the Guanica sugar *central*, San Germán, Mayagüez, Aguadilla, Arecibo, Manatí, and thence to Río Piedras. On the afternoon of April 2 a brief trip to the Caribbean National Forest and Luquillo Mountains was scheduled. Following adjournment several participants in the conference engaged in individual studies and surveys under the direction of personnel of the Agricultural Experiment Station of the University of Puerto Rico.

The conclusions reached and recommendations offered by the three committees, and approved by the Drafting Steering Committee, fill 16 pages. Notwithstanding the presentation of 52 papers at the conference, the dominant theme of the recommendations is for more definitive work in practically every phase of soil science. Special points stressed include the unevenness of geological coverage and the urgent need for more geological studies, particularly in those islands where little, if any, systematic work has been done; the urgent need for aerial and ground surveys leading to the preparation of standardized base maps for detailed areal work; the need for more climatological data, for standardization of field and laboratory procedures in soil surveys, and for assistance in soil classification; the dire need for technical personnel

to ensure proper land use through erosion control and other conservation methods; the lack of sufficient financial support for the preparation of adequate base maps for the inauguration of scientific land use programs; lack of funds and personnel for research in land management. The conference concluded its recommendations by urging "that each Caribbean territory that has not already done so initiate within its boundaries a comprehensive land improvement programme; and that a high degree of coordination of effort be maintained as between the various territories in the planning and carrying out of these programmes." The programs recommended comprise soil surveys, classification, and research; land capability surveys and classification; farm management surveys and research; economic land-use classification; specific land utilization programs, including soil and water conservation. Frank recognition is given to the most vital requirements—financial support on the part of the several governments and trained technical personnel. In a region where the land and its productivity comprise the chief resource of growing populations, proper and efficient land use, which depends upon full and complete knowledge of the soils, becomes the *sine qua non* of progress, and even of survival.

Curt Stern, professor of zoology, University of California at Berkeley, has been appointed to the Atomic Energy Commission's advisory committee on biology and medicine, for a three-year term. Dr. Stern replaces **G. W. Beadle**, of the California Institute of Technology, retiring member of the committee.

Delegates appointed by Detlev W. Bronk, president of the National Research Council, to attend the meeting of the International Commission of Optics of the International Union of Pure and Applied Physics, to be held in London, July 17–20, are: **Irvine C. Gardner**, National Bureau of Standards, **Rudolf Kingslake**, Eastman Kodak Company, **Stanley S. Ballard** (chairman of the U. S. national committee of the commission), Tufts College, and **David S. Gray**, of the Polaroid Corporation, who will serve as alternate.

Harry Beevers, of Oxford University, England, has been appointed visiting professor of plant physiology in the Department of Biological Sciences of Purdue University for 1950–51. He will present a series of lectures and direct research in mineral nutrition of plants.

Mario G. Levi, professor of industrial chemistry and director of the College of Engineering, Milan, Italy, has been elected president of the Associazione Italiana di Chimica.

Silvano Rossi, senior research worker of the Consejo Superior de Investigaciones Científicas, Spain, has been appointed professor of radiobiology at the University of Tucumán, Argentina. Dr. Rossi is working at present in the Institute of Physiology at Tucumán, and will be in charge of the organization of the Institute of Roentgenology and Physical Therapy with a center for studies in the fields of radiobiology and experimental oncology.

Visitors to U. S.

Stig G. Anvill, research engineer, Surahammars Bruk, Surahammar, Sweden; **Per V. Bruel**, director of Bruel and Kjaer, Naerum, Denmark; **M. V. Deshpande**, lecturer in electrical engineering, College of Engineering, Poona, India; **Stig Giertz-Hedstrom**, president, Vibro-Plus Corporation, Stockholm, Sweden; **Roberto S. Nasser**, chief chemist, S. A. Fabricas Orion, São Paulo, Brazil; **Enrique Futierres Rios**, professor of inorganic chemistry, University of Granada, Spain; and **Juan L. M. Vivaldi**, member of the Consejo Superior de Investigaciones Científicas, attached to the Instituto de Edapologia (Soil Study) at the university, visited the National Bureau of Standards recently.

A. Buzzati-Traverso, of Pavia, Italy, lectured June 20 at the Conference on Genetics of Heterosis being held at Iowa State University (*Science*, April 21, 451). **E. S. Wellhausen**, of the Rockefeller Foundation, Mexico City, will give a lecture on "Heterosis in a New Population," on July 11.

Awards

The 1950 Barnard Gold Medal of Columbia University for meritorious service to science has been awarded to Enrico Fermi, nuclear physicist at the University of Chicago. This award, normally given every five years, had not been made since 1940.

The National Tuberculosis Association has awarded its **Trudeau Medal** for 1950 to John B. Barnwell, chief of the Tuberculosis Division of the Veterans Administration Department of Medicine and Surgery.

The 1949 Lamme Medal of the American Institute of Electrical Engineers was presented to C. M. Laffoon, manager of the A-C Engineering Department, Westinghouse Electrical Corporation, at the annual meeting of the institute, June 12, in Pasadena, California.

Tilly Edinger, research paleontologist at the Museum of Comparative Zoology, Harvard University, has been awarded the **National Crusade Fellowship of the American Association of University Women** for foreign travel in connection with the preparation of a new edition of her book on fossil brains.

Meetings and Elections

Approximately 1,300 botanists from 30 nations have given notice of their participation in the **Seventh International Botanical Congress**, to be held in Stockholm, Sweden, July 12–20. Further notifications are expected. In addition to the main proceedings in the capital, the agenda includes a number of excursions and study trips by the fifteen congressional sections to all representative areas of Sweden. The largest number of excursions is allotted to the Vegetative Geography Section, headed by Einar Du Rietz. The first trip starts on June 27 to

eastern Scania, Blekinge, Oeland, and Gotland. Another expedition will be made through the Vestergotland and Smaland bogs; a third will be devoted to the Halland-Bohuslän littoral in West Sweden. By way of contrast to Smaland's coniferous forests, a trip has been planned through the deciduous forest areas in Scania and Blekinge to Mt. Omberg in Oestergotland. There will be a one-day excursion for all delegates among the outermost skerries of the Stockholm archipelago. Upon conclusion of official business, a trip will be made to study algae in the Öregrund archipelago north of Stockholm, the lakes of Upland and Dalecarlia, and Abisko in North Lapland.

The Electron Microscope Society of America will hold its eighth annual meeting September 14–16 at the Hotel Statler in Detroit, Michigan. Further information may be obtained from the program chairman, F. A. Hamm, General Aniline and Film Corporation, Easton, Pennsylvania.

The Eighth Annual Pittsburgh Conference on X-Ray and Electron Diffraction will be held November 2–3 at the Mellon Institute for Industrial Research in Pittsburgh. Papers are invited on small-angle scattering, instrumentation and techniques, applications in the fields of metals and silicate chemistry, and related subjects. Titles should be sent to the chairman of the program committee, L. H. Hofer, Bureau of Mines, Bruceton, Pennsylvania, before *August 15*. Papers will be considered in the order in which they are received.

The Illuminating Engineering Society has elected the following officers for 1950–51: president, Walter Sturrock, General Electric Company; vice president, E. M. Strong, Cornell University; treasurer, R. F. Hartenstein, Ohio Edison Company; and general secretary, A. H. Manwaring, Philadelphia Electrical and Manufacturing Company.

The National Board of Medical Examiners held its annual meeting on May 3 in Philadelphia. Howard T. Karsner, medical research advisor to the Surgeon General of the Navy, was elected president of the board for a term of three years. Other officers elected were Everett S. Elwood, executive secretary and treasurer, J. S. Rodman, medical secretary, and John P. Hubbard, associate secretary.

The Minnesota Academy of Science has elected the following officers for 1950–51: president, A. N. Wilcox, University of Minnesota; vice president, W. C. Croxton, State Teachers College, St. Cloud; secretary-treasurer, Shirley P. Miller, Augsburg College, Minneapolis.

Deaths

Trigant Burrow, 74, psychiatrist and initiator of phylobiology—a science dealing with the interrelational behavior of man—died May 24 at his home at Greens Farms, Connecticut, after several months' illness. Dr. Burrow, scientific director of the Lifwynn Foundation for Laboratory Research in Analytic and Social Psychiatry since its establishment in 1927, was also a founder and former president of the American Psychoanalytical Association.

Edward A. Birge, president emeritus of the University of Wisconsin since 1925, died June 9 in Madison, at the age of 98. Dr. Birge, who joined the faculty of the university in 1875 as an instructor in natural science, was an authority on limnology.

Oakes Ames, 75, professor emeritus of botany at Harvard University, and former director of the university's Botanical Museum, died April 28 at his home in Ormond, Florida. Dr. Ames had devoted his life to the study of orchids and in 1941 his collection of more than 64,000 specimens was presented to the Harvard Botanical Museum.

Herbert Spencer Barber, 68, entomologist of the U. S. Department of Agriculture, died of a heart attack, June 1, at his home in Washington, D. C. Dr. Barber, a well-known coleopterist, served with the Division of Insect Identification of the Bureau of Entomology and Plant Quarantine from 1908 until his death.

Gustav Ernst Fredrik Lundell, retired chief of the Chemistry Division, National Bureau of Standards, died in Baltimore, June 8, at the age of 69. Dr. Lundell was in charge of developing methods of analyzing and purifying graphite and uranium to make possible their use in the first atomic pile, during World War II.

Miscellaneous

A registry of hepatic pathology, sponsored by the American Gastroenterological Society, has been established at the American Registry of Pathology, administered under the auspices of the National Research Council. Liver specimens obtained by biopsy or autopsy, accompanied by pertinent laboratory and clinical records, will be collected, and will be available for research. Material contributed will be reviewed by the Armed Forces Institute of Pathology, and contributors will receive an opinion concerning it. Material should be submitted through a pathologist on forms obtained from the institute; one stained and five unstained sections of liver biopsy specimens are requested, and one stained section and paraffin blocks or wet tissues of autopsy material. Specimens should be sent to the Director, Armed Forces Institute of Pathology, Registry of Hepatic Pathology, Washington 25, D. C.

The British Commonwealth Scientific Office for North America recently moved to 1800 K street, N.W., Washington, D. C. The individual missions constituting the office are: United Kingdom Scientific Mission, Canadian (NRC) Scientific Liaison Office, Australian Scientific Research Liaison Office, New Zealand Scientific Liaison Office, and South African Scientific Liaison Office.

German Aviation Medicine, World War II, a two-volume publication making available to American scientists original and unpublished research accomplished in Germany during the war, will be published by the U. S. Government Printing Office, June 30. The greater part of the data presented is directly concerned with aviation medicine, but there are

also descriptions of scientific equipment, and data on researches in physiology, biophysics, psychology, and pathology. The publication was sponsored by the U. S. Air Force and was made possible through the work of the Air Force Surgeon General and School of Aviation Medicine. Fifty-seven German scientists, specialists in their fields, aided in preparing the work—conducting further research, reviewing and evaluating German documents, and translating.

A new scientific program, **Science for the People,** is being broadcast over Station WEVD (1330 Kc), New York City, every Friday evening at 8:45. The program is written and produced by W. Wendell Rázim, chemist, meterologist, and consultant technical writer. As one of his sources of information Mr. Rázim will use advance proofs of *The Scientific Monthly* in preparing some of his broadcasts; a similar arrangement is in effect with the University of Denver, which has been broadcasting items from *The Scientific Monthly* over Stations KVOR, KGHF, KFKA, KLZ, and KFXJ since November, 1949.

The Chicago Research Group, a new organization for the development and exploitation of chemical processes and products, has set up offices at 9 South Clinton Street, Chicago. Primary interest will be in products of a patentable nature, and in some instances research on inventions of independent inventors will be financed. Members of the new organization are Carl S. Miner, director of Miner Laboratories, Hoy A. Cranston, director of the Laboratory of Polarographic Analysis, A. Sidney Behrman, chemical consultant, and Franklin M. Warden, patent lawyer.

A campaign against malaria and other acute disease problems in the Hanoi and Saigon regions of Indo-China will be aided by a group of U. S. Public Health Service officers assigned to the Health Division of the ECA Special Technical and Economic Mission to Vietnam, Laos, and Cambodia. The program, under the direction of John Grant, acting chief of the Health Division of the mission, will include spraying dwellings in designated areas with DDT, and some therapy for infectious diseases. Personnel will be recruited in local areas to assist in carrying out field operations. Specific objectives planned for the program, recruitment, and assignment of personnel have been handled by the Division of International Health of the Public Health Service. Supplies of DDT, penicillin, chloroquine, and other drugs will be provided by ECA. Members of the present team of specialists, part of a larger contingent expected to be assigned later, are: Frank Tetzlaff, sanitary engineer, Federal Security Agency regional office, New York City; F. Earle Lyman, assistant chief, Entomology Branch, Communicable Disease Center, Atlanta; Gustave C. Schram, venereal disease expert, Eastern Medical Center, Durham, North Carolina; Harry D. Pratt, chief, Medical Entomology Section, Laboratory Branch, Communicable Disease Center; and William J. Buchanan, sanitary engineer, FSA regional office, San Francisco.

A bimonthly magazine will be published by the **American Cancer Society** this fall. The new publication will bring doctors up to date on developments in cancer diagnosis, treatment, and care of patients. A number of the society's state divisions plan to subscribe to the magazine for all practicing physicians within their areas.

A new national commission on chronic illness has established headquarters at 535 North Dearborn Street, Chicago. The commission is engaged in an education-research program and represents the first national unified approach to the common problems of long term illness. Agencies which have pledged financial support are the American Cancer Society, American Heart Association, American Medical Association, National Foundation for Infantile Paralysis, National Tuberculosis Association, National Society for Crippled Children and Adults, and the New York Foundation. A model community survey plan is being developed for use by communities interested in studying their local needs, services, and facilities. The plan will be tested in several communities this summer before it is presented for use throughout the country. Plans have also been drawn up for a study of prevalence and medical needs in an urban and a rural area.

Meetings Abroad

Eighth International Congress of Agricultural Industries, July 1–15, Brussels, Belgium.

First International Congress of Cardiology, July 1–15, Paris.

First International Microchemical Congress, July 2–6, Graz, Austria.

International Conference on CO_2 Fixation, July 3–7, Sheffield, England.

International Union of Biological Sciences, July 7–11, Stockholm.

First International Conference of Gerontological Societies, July 9–12, Liége, Belgium.

Fourth Plenary World Power Conference, July 10–15, London.

Conference on Properties of Semiconducting Materials, July 10–15, University of Reading, Reading, England.

Seventh International Botanical Congress, July 12–20, Stockholm.

Fifth International Cancer Congress, July 17–22, Paris.

International Congress for Scientific Research, July 17–22, Sorbonne, Paris.

International Meeting for Optical Science, July 17–26, London.

16th International Congress of Ophthalmology, July 17–26, London.

London Conference on Optical Instruments, July 19–26, Imperial College of Science and Technology, South Kensington, England.

International Latin-American Congress of Psychology, July 20–30, Montevideo, Uruguay.

Sixth International Congress of Pediatrics, July 21–30, Zurich, Switzerland.

Sixth International Congress of Radiology, July 23–30, London.

Fourth International Congress of Soil Science, July 24–August 1, Oslo, Norway.

International Anatomical Congress, July 25–28, Oxford, England.

Timely McGRAW-HILL Books

TRANSMISSION LINES AND NETWORKS

By WALTER C. JOHNSON, Princeton University. *McGraw-Hill Series in Electrical and Electronic Engineering.* Ready in summer

Provides a unified treatment of the theory of transmission lines and four-terminal networks, with application to both the power and communication fields. Part I. first discusses transmission lines in a general manner and then introduces special considerations relating to the separate fields of power transmission. Part II. treats the general theory of four-terminal networks, which is then applied to attenuators, impedance matching networks, and filters.

VECTOR AND TENSOR ANALYSIS

By HARRY LASS, University of Illinois. 347 pages, $4.50

A basic textbook for college juniors and seniors. The purpose of the book is to acquaint the student with the methods and tools of vector and tensor analysis as applied to geometry, mechanics, electricity, hydrodynamics and the theory of relativity, and to prepare him for more advanced work in theoretical physics.

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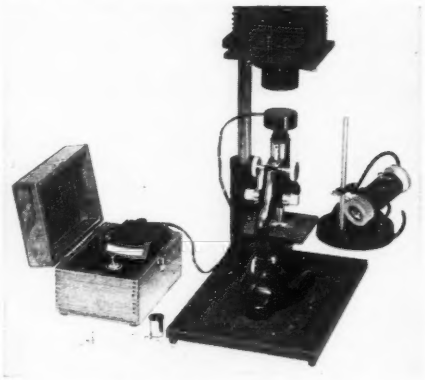

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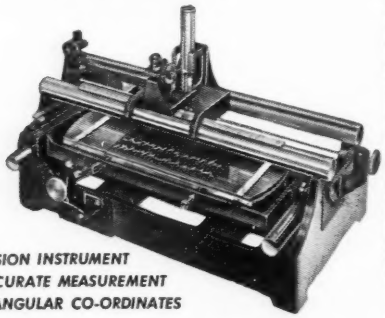

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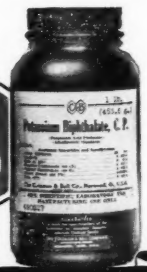

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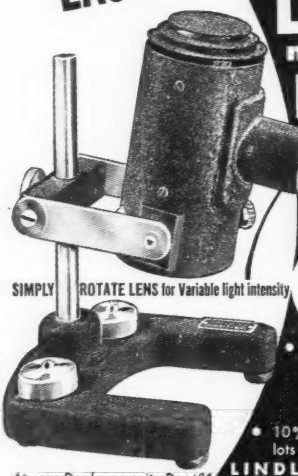

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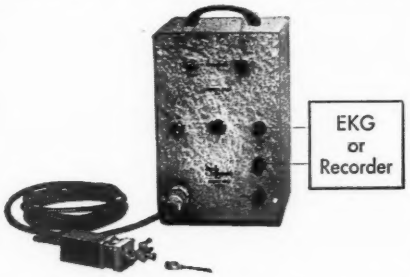

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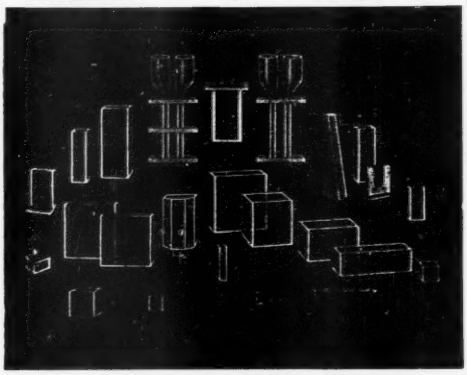

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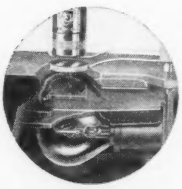

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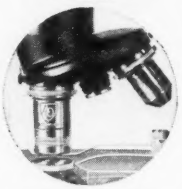

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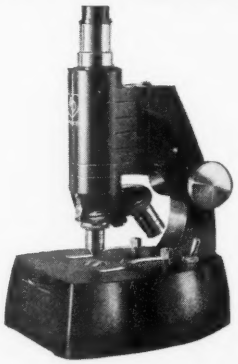

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